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ABSTRACT

This student reference booklet is designed to accompany lessons outlined in the companion instructor's guide on soil conservation. The soil conservation unit builds on competencies gained in Agricultural Science I and II. Informative material is provided for these eight lessons: benefits of conservation, land utilization, how soils are eroded, cropping and reduced tillage systems, no-till farming, erosion control structures, universal soil loss equation, and agency assistance. (YLB)

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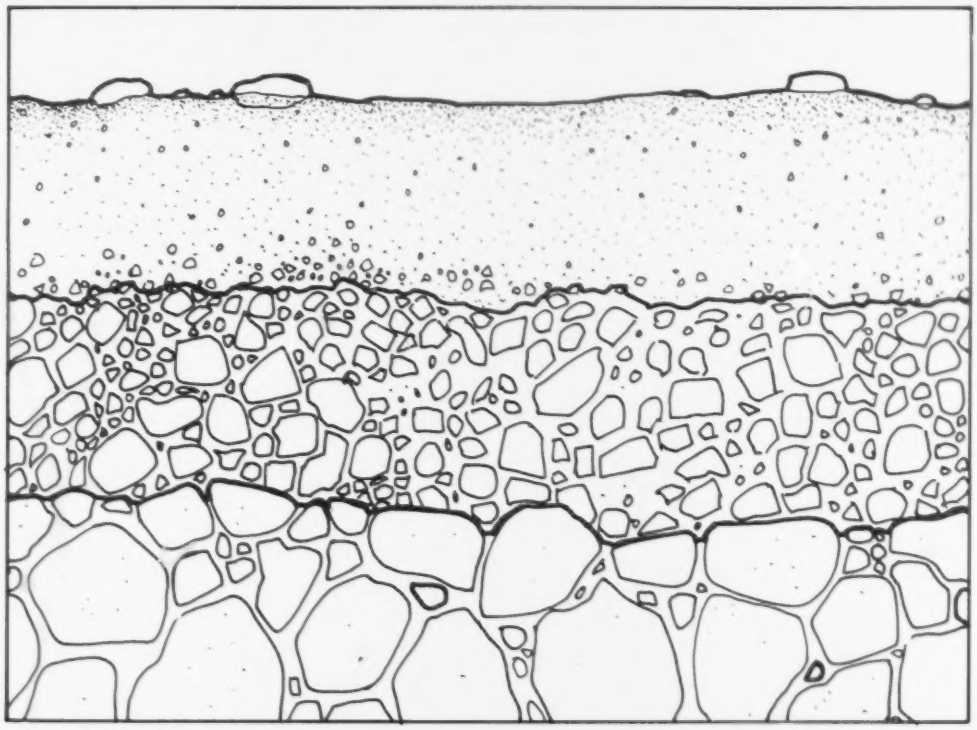
MISSOURI AGRICULTURAL EDUCATION

AG-109-S
AGDEX 570

# Soil Conservation Unit

ED 287089



## for the Advanced Crop Production and Marketing Course

### Student Reference

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Student Reference

# SOIL CONSERVATION UNIT

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# FOREWORD

The Soil Conservation unit, a part of the Advanced Crops curriculum, builds on competencies gained in Agricultural Science I and II. An instructor's guide and student reference have been developed to facilitate the teaching/learning process.

The material consists of eight competency-based lessons: Benefits of Conservation, Land Utilization, How Soils Are Eroded, Cropping and Reduced Tillage Systems, No-Till Farming, Erosion Control Structures, Universal Soil Loss Equation and Agency Assistance.

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SOIL CONSERVATION

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UNIT - SOIL CONSERVATION

Lesson 1: Benefits of Conservation

Concern over soil erosion and conservation practices is not new. The Bible records these words of Job: "The waters wear away the stones; the torrents wash away the soil of the earth; so thou destroyest the hope of man."

Abandoned farmsteads are mute testimonies of the destruction of the hopes of many farm families. Some of these farms are a product of changing times, but many were brought about by the destructive nature of erosion.

**U.S. Conservation History**

Early American conservationists - Many early Americans were conscious of the destructive force of erosion. George Washington, our nation's first president, wrote extensively about soil losses from erosion. He mentioned with disfavor the exploitation of our natural resources during the colonial days and encouraged the use of conservation measures. Thomas Jefferson, the third president of the U.S., was a large landholder in Virginia. When asked why his land was being farmed on the contour, he replied, "A nation's wealth may be measured by the depth of its topsoil." And nearly every student knows about Patrick Henry and his famous declaration made during his fiery speech for independence: "Give me liberty or give me death." Patrick Henry also said on another occasion, "He is the greatest patriot who saves the most soil."

Missouri pioneering efforts - Sanborn Field, a National Historic Site on the University of Missouri-Columbia campus, was established in 1888 and is the oldest experiment field west of the Mississippi.

Missouri agricultural research was expanded in 1917 with the establishment of Station Field on the University of Missouri campus to study the effects of drought, fertility, rainfall, soil moisture and runoff. Soil loss was added later as a significant part of Station Field research. The work done there set the pattern for other erosion studies throughout the nation.

Missouri has been a leader in determining the causes of erosion and how it could be controlled, especially through work at experiment stations in Columbia, Bethany and McCredie. A sign at the Station Field site in Columbia states that these runoff and erosion studies started in 1917 "provided the foundation for the soil conservation movement."

Effective conservation work has been done in Missouri, but the task is far from complete. The 1982 National Resources Inventory estimated that 54% of Missouri's 14,261,200 cropland acres still need erosion control treatment. (See Table 1.1 that follows.)

TABLE 1.1 - Missouri agricultural land and its conservation needs

| Agricultural use | Total acres | % needing conservation |
|---|---|---|
| Cropland (non-irrigated) ..... | 14,261,200 | 65% |
| Pastureland ..... | 12,573,000 | 63% |
| Rangeland ..... | 167,800 | 79% |
| Grazed forest land ..... | 2,999,600 | 86% |
| Farmsteads, other land ..... | 706,800 | 28% |

Recent-day conservationists - The 1930s brought an awakening on the part of a great many people to the seriousness of erosion and the need for conservation. The depressed economy and Dust Bowl effects stirred public interest in conservation.

Agricultural leaders and agricultural colleges had for several decades been involved in erosion, soil fertility and cropping system studies at erosion experiment stations. But one of the men who really led the soil conservation movement was Hugh Bennett. Bennett became a forceful speaker and spoke so strongly on the subject that he has been called the "fiery apostle" and "the father of soil conservation."

In 1935 Congress enacted the Soil Conservation Act establishing the Soil Conservation Service under the Department of Agriculture. Bennett became the first SCS chief. He received strong support from many political figures who were also concerned about the need for soil conservation. Primary among them was Franklin D. Roosevelt. Pres. Roosevelt approved of Bennett's enlistment of help from the Civilian Conservation Corps. In 1937 he wrote a letter to all the state governors urging them to set up soil conservation districts to work with the Soil Conservation Service. In that letter he said, "The nation that destroys its soil destroys itself."

Government programs - In 1938, legislation enacted the Soil and Water Conservation Districts at the national level to provide assistance to states through soil conservation districts. Farmers and ranchers, working voluntarily with SCS employees, began changing farming practices and healing Dust Bowl damage. For the next two decades, the conservation movement's effects snowballed with additional government programs and local efforts.

**Early American Attitudes**

The colonial period in America was one of great exploitation by the early settlers. Fields, cleared from the forests, were planted to the same crops year after year. The topsoil on these fields was rapidly washed away. The philosophy of most of the settlers was that it did not matter because the fields that became unproductive could just be abandoned and new lands brought under cultivation.

Some people still use farming practices that accelerate erosion. Largely, it is because they are uninformed, are not aware of the disastrous effects of

erosion, are apprehensive about adopting conservation farming techniques or "have always farmed that way."

**Erosive Affects on Topsoil**

Erosion is defined as the group of processes by which earthy or rock material is removed from any part of the earth's surface.

It is now recognized that topsoil is a limited resource. Under good conditions, it takes 150-1,000 years to form one inch of topsoil. This thin, fertile layer lies over much of the earth's surface. It produces our food as well as most of our clothing and shelter. Topsoil is an absolutely essential natural resource which is both limited and fragile. The underlying subsoils, because they are low in fertility, organic matter and water-holding capacity, cannot supply adequate food, clothing and shelter to sustain life as it is on earth today.

Some Missouri soils had as much as 16-18 inches of topsoil when first settled. Because of soil erosion, up to half of that topsoil has been lost. There are many fields where subsoil shows on the surface. This topsoil loss happens because the soil is subjected to erosion. Falling raindrops dislodge the soil and splash it into solution. The soil particles are carried off the field with the running water, and with them go nutrients, organic matter, fertilizers and pesticides. Signs of erosion are silt fans at the bottom of slopes, silt in road ditches, sediment in streams, small ditches in fields and thin topsoil.

It is no secret that Missouri ranks in the top five states in cropland erosion rates. (See Table 1.2 and Figure 1.1.) According to the Missouri Department of Natural Resources, 200 million tons of soil erode each year from the state's croplands. That is enough soil to fill enough 10-ton dump trucks that would stretch around the world three times.

TABLE 1.2 - "Top 10" of estimated sheet & rill erosion for cultivated cropland

| | State | Tons/A | | State | Tons/A |
|---|---|---|---|---|---|
| 1. | Kentucky | 11.7 | 6. | Pennsylvania | 7.7 |
| 2. | Tennessee | 11.5 | 7. | Mississippi | 7.6 |
| 3. | Missouri | 11.0 | | Alabama | 7.6 |
| 4. | Iowa | 9.6 | 8. | Illinois | 7.1 |
| 5. | Virginia | 7.9 | | Massachusetts | 7.1 |

**Erosion and Crop Production**

In a 19-year controlled experiment at the University of Missouri, Professor C. M. Woodruff compared corn yields on eroded and uneroded areas. Both areas had equal fertilizer treatment. He found that uneroded areas produced 44 bushels more corn on each acre than did severely eroded areas.

In 1971-72, University of Missouri Professor Robert Beasley conducted a survey on the effects of erosion in Missouri. He concluded that soils with 12 inches of topsoil produced an average of 110 bushels of corn and 43 bushels of soybeans per acre, while severely eroded soils produced an average of 83 bushels of corn and 24 bushels of soybeans per acre.

In addition to these studies, in 1982 the Soil Conservation Service did yield studies on 28 fields in Missouri. Soil scientists located points in each field where the topsoil depth varied. One point had 12 inches of topsoil (slight erosion), another five inches (moderate erosion) and the third had three inches of topsoil (severe erosion). Each of the fields were planted in either corn, soybeans or wheat. On every field, each point had equivalent variables except for topsoil depth. In the fall of 1982, the points were relocated and the crop harvested and brought to uniform moisture levels. Yields were then computed for each point.

Corn yields varied the most. There was a 25% reduction in the average yields between the slightly eroded areas and the moderately eroded areas, and a 49% reduction in the severely eroded areas. Soybean yields dropped 9% in the moderately eroded areas and 28% in the severely eroded. Wheat yields dropped 12% and 41% respectively.

A heavy sediment load in rivers or ponds can result in silt covering the eggs or clogging the breathing apparatus of an aquatic organism, causing suffocation. Also, increased water turbidity has a negative affect on fish species which feed by sight, such as bluegill and bass.

**Other Problems Caused by Soil Erosion**

Research studies have found that eroded soils have poorer stands, increased production costs and decreased net income. Farming subsoils takes more fuel and fertilizer than does farming topsoil. The sediment from eroding fields fills road ditches, stream channels, ponds and lakes. Downstream cities must separate the soil particles from the water so it can be used for human consumption. Flooding potential increases as stream and river channels fill with sediment and lose carrying capacity.

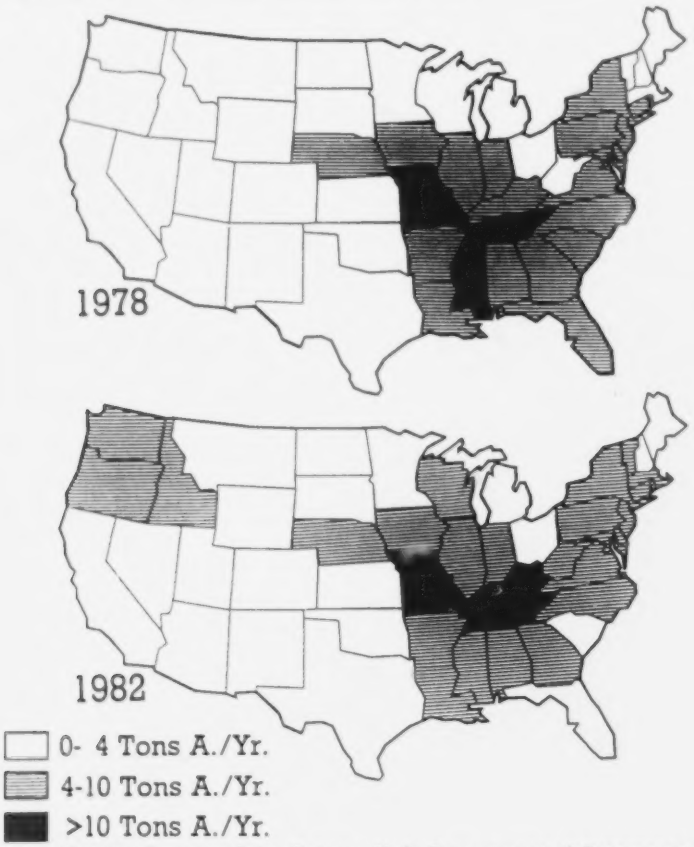
Offsite damages are prevalent with flat, graded soils in the Bootheel. Tail ditches, which lead to main ditches, can fill with eroded soil. If these tail ditches are not dredged or cleaned, affected fields will have poor drainage.

A heavy sediment load in rivers or ponds can result in silt covering the eggs or clogging the breathing apparatus of an aquatic organism, causing suffocation. Also, increased water turbidity has a negative affect on fish species which feed by sight, such as bluegill and bass.

**Summary**

Good productive topsoil is not an inexhaustible resource. Missouri cannot continue to lose topsoil at current rates and remain a productive agricultural state.

FIGURE 1.1 - Sheet and rill erosion for cropland




Credits: Bureau of the Census, U. S. Department of Commerce.
1982 National Resources Directory, USDA.

**Credits**

UMC Extension Division publications

a) M117: Best Management Practices for Erosion and Sediment Control
b) MX121: Conservation Tillage Considerations for Missouri Farmers

Soil and Water Conservation: The Principle and Practice. Columbia: University of Missouri-Columbia Special Report 290.

"Topsoil: Our Vital Resource." Missouri Association of Soil and Water Conservation Districts, 1983.

1982 National Resources Inventory. USDA.

Soil Conservation Policies: An Assessment. Ankeny, Iowa: Soil Conservation Society of America, 1979.

UNIT - SOIL CONSERVATION

Lesson 2: Land Utilization

Selecting the proper use of different kinds of land on the farm is the first and most important step in conserving soil. The success of all other phases of the farm's conservation program will depend on the selection of a land use pattern that is within the land's capability.

Determining the proper use for each field is partly a matter of deciding whether each field is best suited for crops, pasture, woods, wildlife or recreation. This requires a knowledge and evaluation of the physical features found on the farm. The best farming methods must be chosen within the capability of the land.

**Taking a Soil Survey or Inventory**

Gathering facts about the land is the essence of taking a soil survey or inventory. The USDA Soil Conservation Service has soil surveys available for most counties in Missouri. A soil survey publication contains the informational building blocks for land use planning.

Depth of soil material - This concerns the combined depth of surface soil and favorable subsoil where the plant roots can function well. Soil material depth is determined by use of a soil probe, auger or spade. The presence of any soil layer which severely restricts or prevents necessary root development will limit the effective depth of a soil. Common restrictive layers are rock layers; dense chert layers; sand or gravel layers; and hardpan, claypan or siltpan layers. There are three basic soil depths.

1. Deep: combined thickness of the favorable surface soil and subsoil is 40 inches or greater
2. Moderately deep: the presence of a limiting or restrictive layer occurs within 20-40 inches of the top of the soil
3. Shallow: the presence of a limiting or restrictive layer occurs within 20 inches of the top of the soil

Air and water movement - A soil having a favorable air/water relationship must hold ample moisture to supply the needs of the crop between rains, yet permit water to pass through the soil to prevent waterlogging and excess moisture. This relationship, or exchange of air and water in the soil, has a great effect on the kind of crops that can be grown, how soon the soil dries after a rain, benefits that can be expected from fertilizers, and water availability to plants during wet and dry periods.

Subsoil color is one clue to the air/water relationship of a given soil. Just as iron will oxidize or rust when exposed to intermittent wetting and drying, so will a soil oxidize under favorable air/water movement. A well-oxidized soil has bright colors of red, yellow or brown in the subsoil. A subsoil with much water and too little air will not oxidize well; the colors will be dull or grey, frequently mixed or mottled with gray, black, yellow or brown. For

general purposes, the air/water characteristics of most soils can be grouped into one of the following categories.

1. Rapid: Water and air movement is slightly faster than desirable. Water moves through the soil rapidly, and the soil does not hold enough moisture for favorable soil functions. Soils will be droughty and normally allow two inches of water to pass through them in an hour. Subsoil colors will be very bright.
2. Moderate: This is the most favorable condition of air/water movement--just right for normal soil functions. Moderate water movement is considered to be .6-2.0 inches per hour. If free drainage exists, the soil has a well-oxidized subsoil indicated by bright colors such as red, yellow or brown.
3. Moderately slow: Water moves through the soil a little slower than is desirable for best results. Moderately slow water movement through the soil is measured at .2-.6 inches per hour. Subsoil in this case is less oxidized, and colors will be bright in the upper part with dull gray or mixed colors in lower subsoil.
4. Slow: Water moves through the soil at a slow rate, and soil remains quite wet following rainy periods. Timely seasonal operations are often delayed. Slow water movement is .06-.2 inches per hour. This condition is characterized by dull gray or mixed and mottled dull colors throughout the subsoil.
5. Very slow: Water movement is so slow that sufficient air cannot get into the soil and it remains wet and waterlogged for rather lengthy periods. Water movement in these soils is generally .06 inches per hour or less. These soils are not well adapted for many crops. Soils of this kind have gray coloring in the lower part of the surface soil and are usually very heavy.

Color of surface soil - In most parts of Missouri the darkness of a soil is a good guide to its inherent fertility. In judging soil color, there are three categories.

1. Dark: These include the black and dark brown surface soils which usually indicate a high inherent fertility.
2. Moderately dark: These include the dark gray, grayish brown and light brown surface soils, indicating a moderate inherent fertility.
3. Light: This includes brownish gray, gray or light gray surfaces, indicating a low or very low inherent fertility level.

The surface soil color can be determined by looking at a handful of soil when it is moist. After judging inherent fertility, soil tests are needed to determine the current fertility needs.

Texture of soil - The size of soil particles is important in the influence on a soil's ability to take up and release moisture, the ease of tillage and the character of the seedbed. There are three general categories for classifying land.

1. Silty: These soils have a favorable mixture of sand, silt and clay, neither too heavy or too light. The soils in this category are usually a silt or sandy silt.
2. Clayey: These soils contain so much clay that the texture is sticky and gumbo-like. They are often too wet to work and remain hard and cloddy when dry. The soils in this category are usually clay or silty clay.
3. Sandy: These soils have a texture that is very sandy and coarse and will not hold together. Such a soil requires a great deal of water and fertilizers for good plant growth. The soils in this category are usually sand or sandy silt.

Soil texture may be determined in the field by feeling the soil between the thumb and forefinger. First, determine whether the soil is clayey by trying to squeeze a moistened sample of the soil into a ribbon. A moist clay will form a ribbon or a wire. A clay silt will form a ribbon or wire, but not as long or durable as that formed by clay. Some silt soils can be formed into a short ribbon, but others will not form any.

The second step is to decide if the sample is silty or sandy. The sample should be wetter for this step. Silty soil will feel smooth and floury when wet. Sand will feel gritty. Thus, a soil forming a good ribbon with a smooth feel would be a clayey-silt, or one forming a poor ribbon with a gritty feel would be a sandy silt. Soil texture can also be determined from soil surveys.

Steepness of slope - This factor is important because of its influence on the speed water runs off a field and the amount of eroded soil. For classifying the slope of land per 100 foot fall, the following categories can be used.

1. Nearly level: Land that is flat or nearly flat; usually less than two feet fall
2. Gently sloping: Land that slopes very gently and usually has no abrupt changes; 2-5 feet of fall
3. Moderately sloping: Land that has considerable slope and usually some irregularity; normally 5-9 foot fall
4. Strongly sloping: Land that slopes 9-14 feet; usually has considerable irregularity
5. Moderately steep: Land that breaks sharply and has 14-20 feet of fall
6. Very steep: Land that slopes very abruptly and is very steep; 20-35 foot of fall or more

Approximate slopes are available on soil survey maps. Actual slopes of particular areas are determined using levels.

Degree of erosion - The depth of topsoil remaining can be measured by digging into the surface soil or observing a furrow slice behind the plow. The following grouping of soil classes is generally used.

1. No apparent erosion: Nearly all of the original topsoil remaining; no apparent erosion

2. Moderate erosion: Top 6-7 inches of original topsoil remaining; occasional subsoil spots on surface
3. Severe erosion: Top 6-7 inches of mixed topsoil and subsoil; numerous subsoil spots on surface
4. Very severe erosion: Topsoil nearly gone; top 6-7 inches mostly subsoil
5. Very severely gullied: Topsoil nearly gone; numerous gullies

**Land Capability Classifications**

A standard land capability classification system is in use in the U.S. It divides soils into groups with similar problems and potential uses within land resource areas.

Classes I-IV include lands suited for cropland; Classes V-VIII are lands best suited for permanent vegetation. These classes are designated by different colors on capability maps and are standard throughout the country. The following are descriptions of the eight land use capability classes.

Class I - colored light green on land capability maps. Class I is very good land from all features. It is nearly level, soil is deep and easy to work, it holds water well and it is fairly fertile. It can be safely used (though it should be managed to maintain fertility) and shows good physical characteristics.

Class II - colored yellow on maps. Class II consists of soils subject to moderate limitations in use. They can be cultivated with easily applied practices. Soils in Class II have gentle slopes, are subject to moderate erosion, are of moderate depth, are subject to occasional overflows or are in need of drainage. They may require special practices such as soil conserving rotations, water control devices, or special tillage methods.

Class III - colored red on maps. Class III lands consist of soils subject to severe cropping limitations. They can be used for regular cropping provided they are planted in good rotations and given proper treatment. Soils in this class are moderately to strongly sloping and are subject to more severe erosion or subject to frequent overflow with crop damage. These soils require cropping systems that produce adequate plant cover to protect the soil from erosion and to preserve soil structure. Hay and other sod crops should be grown instead of cultivated sod row crops. A combination of conservation practices are needed to farm the land safely.

Class IV - colored blue on maps. Class IV is composed of soils with very severe permanent limitations or hazards if used for cropland. The soils are fairly good. They may be cultivated occasionally if handled with great care, but for the most part should be kept in permanent hay, sod or forest. Soils in Class IV have unfavorable characteristics. They are frequently on steep slopes and are subject to severe erosion. In some cases the soils may be shallow or only moderately deep, low in fertility, and on moderate slopes.

Class V - colored dark green on land use maps. Class V land is nearly level and not subject to erosion. Because of wetness, climate or some permanent

obstruction (like stones or boulders), it is not suited for cultivation. The soil is deep, however, and the land has few limitations for grazing or for forestry use.

Class VI - designated on maps by orange. Class VI soils should be used for grazing and forestry. The steep slopes and shallow soils are subject to moderate permanent limitations and are unsuited for cultivation. Grazing must be managed to avoid destroying plant cover.

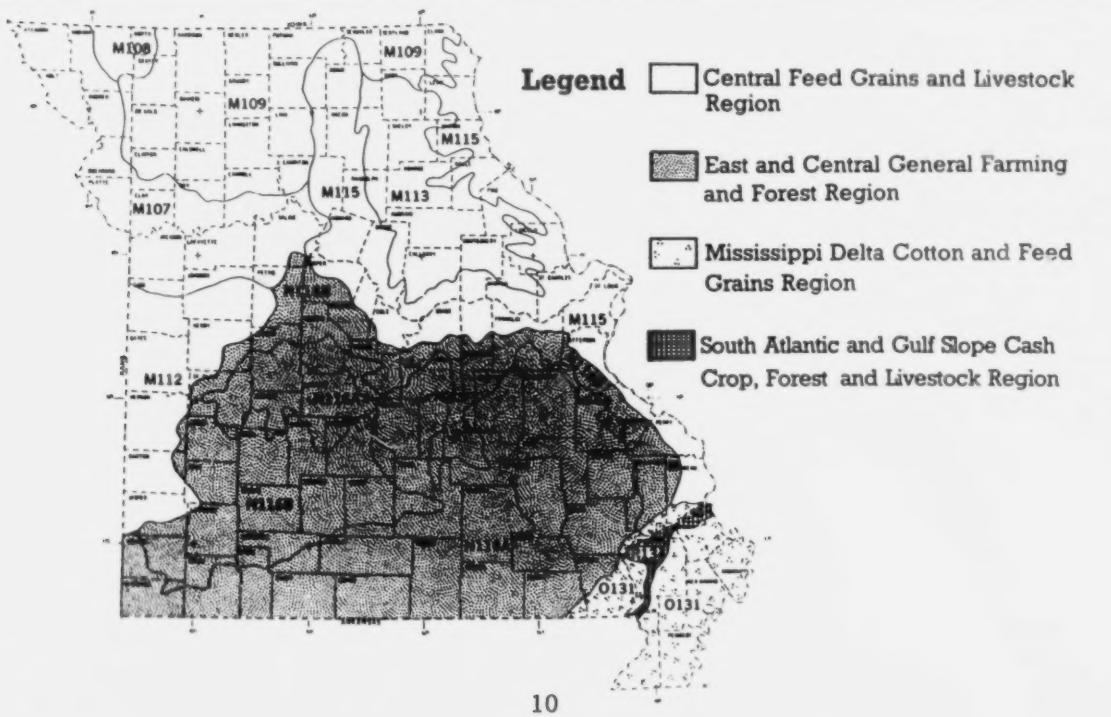
Class VII - colored brown. Class VII soils are subject to severe permanent limitations or hazards when used for grazing or forestry. They are steep, eroded, rough, shallow, droughty or swampy. They are fair to poor for grazing or forestry and must be handled with care. Where rainfall is ample, Class VII land should be used for grazing. In the latter case, strict management should be applied.

Class VIII colored purple on land use maps. Class VIII land is suited only for wildlife or recreational purposes. Usually it is extremely dry, rough, steep, stony, sandy, wet or severely eroded.

**Land Resource Regions and Areas**

Missouri has a good diversity of soils which influence the choice of crops, cropping practices, equipment and other agricultural resources. Missouri has been geographically divided into four Land Resource Regions, which are further divided into Land Resource Areas according to climate, parent material, vegetation use, etc.

FIGURE 2.1 - Land Resource Regions and Land Resource Areas



1. Central Feed Grains and Livestock Region

Deep Loess Hills (LRA M107, M108) - The soils, as the name implies, are deep to very deep loess (windblown) soils on gently rolling to steep slopes. A large area of the Missouri River bottomland is also contained in the area. Much of this area is in cropland, and the percentage has been increasing. Erosion rates in this 8-9 county area are the highest in the state.

Heavy Till Plain (LRA M109) - The soils are fine-textured, highly erodible glacial till on the side slopes with thin loess caps covering the till on the upper landscape positions. The nearly level bottomlands contain variable textured soils, some with high flooding potentials. Typically, one would find cultivated crops on the gently sloping uplands and bottomlands, with pasture and trees on steep slopes and narrow valleys. The cropland acreage has also increased in this area at the expense of sloping pasture areas. Many of these soils contain less than six inches of topsoil and in general contain fertile subsoils. Erosion rates are nearly the highest in the state on cropland in this area.

Cherokee Prairies (LRA M112) - This region is nearly level to gently sloping underland with shale, sandstone and limestone. Soils formed in shale residium are deep claypan soils. Soils formed from sandstone and limestone are more loamy but on narrow ridges are very shallow. There is some dissection of the region with steep slopes and narrow stream valleys. The nearly level to gently sloping areas are intensively farmed, with lower water intake due to the slightly heavier textured surface soil.

Central Claypan (LRA M113) - This area is nearly level to gently sloping with soils formed on thick loess materials covering a glacial till plain. Many of the upland soils have deep claypans formed in the loess. The more sloping areas converge to shallow, narrow stream valleys that are subject to frequent overflow. Sixty to 70% of the area is in cropland, with pasture and forest lands found on the drainage ways and steeper slopes. Erosion rates are 10-11 tons per cultivated cropland acre per year in this area. As topsoil is removed, exposing the less permeable subsoil, erosion rates will increase. Irrigation is becoming a fairly common practice in this area.

Central Mississippi Valley Wooded Slopes (LRA M115) - Soils of the Chariton River Valley are significantly different from those found along the Missouri and Mississippi river areas. One frequently finds very low fertility status soils on the thin loess-cap glacial-till origin soils of the Chariton. Timber and pasture are common in the uplands, with intensive row crop in the bottomlands. Soils along the Mississippi and Missouri rivers are formed in loess, and as one moves a greater distance from the rivers, soils are formed in cherty limestone and dolomite materials. Row crops are more common in the former with timber and pasture in the latter areas.

2. East and Central General Farming and Forest Region

Fragipan soils are numerous in this area, restricting root penetration. In the bottomlands, an examination finds soils in silty, sandy and cherty alluvium materials. Agriculturally, there are over 2,000,000 acres of pasture

which were converted from timber and brush areas. Row crops are found in many of the bottomlands, with timber covering the predominant acres of the uplands. Erosion is found predominantly on pasture and forest areas in the uplands and is a major problem since topsoil is very thin and subsoil materials are extremely infertile.

Ozark Highlands (LRA N116A) - It is difficult to summarize the soils in this area since the soils range from development on narrow cherty limestone ridges in the western part, to more broad cherty limestone ridges in the central, to igneous rock material in the eastern part. Loess occurs in either a very thin mantle or is completely absent. Also included in this area are glade soils which have little depth.

Ozark Border (LRA N116B) - This area also has a large range of soils, especially from west to east. There are soils derived of loess materials over cherty limestone, domolitic and limestone materials and shale materials. Deep soils with significant fragipan are common in upland positions. Cultivation is found on the uplands and in the narrow valleys. Pasture and forest dominate on the steep side slopes and irregular shaped areas. In the steep areas, the loss of topsoil presents serious problems since subsoils are very infertile or contain large amounts of chert materials. Poor management has caused the loss of all topsoil in some locations of the Ozarks.

3. Mississippi Delta Cotton and Feed Grains Region

Southern Mississippi Valley Alluvium (LRA O131) - This is predominantly the Bootheel area with all soils formed in alluvium either in floodplain or terrace positions. Soils are very deep and vary in texture from clay to silty sands. A significantly high portion of the area is in intensive cropland, with a small amount of timber and very little pasture. The major erosional problem is wind erosion.

4. South Atlantic and Gulf Slope
Cash Crop, Forest, and Livestock Region

Southern Mississippi Valley Silty Uplands (LRA P134) - Adjacent to area LRA O131 is LRA P134; Missourians know it as Crowley's Ridge. Crowley's Ridge is a major sloping land form with a loess mantle underlaid by silty, sandy and gravel deposits. Erosion rates are the third highest in the state.

**Summary**

The first step in conserving soil is to select the proper use for the different kinds of land on the farm--whether for crops, pasture, woods, wildlife or recreation. Taking an inventory gathers facts that help decide the best utilization for the land. The U.S. uses a land capability classification system which divides different land features into eight classes. Missouri has been divided into four land resource regions, which are further broken down into land resource areas.

The most severe erosion problems are in the northwest followed by the Heavy Till Plain area in north central Missouri. Crowley's Ridge, a narrow strip

north of the Bootheel, is losing a high amount of soil yearly due to loess soils and sloping land forms.

**Credits**

Hudson, Norman. Soil Conservation. Ithaca, N.Y.: Cornell University Press, 1981.

Bosworth, Duane A. and Albert B. Foster. Approved Practices in Soil Conservation. Danville, Ill.: Interstate, 1982.

UMC Extension Division agricultural publication

a) MX121: Conservation Tillage: Considerations for Missouri Farmers

UNIT - SOIL CONSERVATION

Lesson 3: How Soils Are Eroded

Erosion has always taken place, and some always will. Erosion is essentially a smoothing or leveling process with soil and rock particles being carried, rolled or washed away by gravity's force. The primary breakdown agents are wind and water.

**How Soils Are Eroded**

**Water erosion** is the single most destructive force in Missouri's soil erosion problem. Rainfall, runoff, streams and rivers all scour away soil; wherever water is in movement, it is eroding its boundaries. Rainfall erosion is dependent on the erosivity (of the rain) and the erodibility (of the soil).

Erosion = interaction of rain, soil and the soil cover

Erosivity is the potential ability of rain to cause erosion. It is the function of the physical characteristics of rainfall. Erodibility is the vulnerability or susceptibility of the soil to erosion. It is a function of both the physical characteristics and the management of the soil. So in essence, erosion by rainfall is the interaction of these two items, the rain and the soil. Agriculturalists have the ability to affect the actual erosion rate positively or negatively by the management practices chosen in farming operations.

Soil erosion by water occurs in two steps: 1) the detachment of the soil particles; and 2) the transporting of those particles. The first stage is principally caused by the splash or impact effect of a raindrop. A drop of rain is a high-energy force which can splash more than two feet high, five feet laterally, and fall as fast as 20 mph. In the second stage, soil particles are carried off by the surface flow of water. Conservation practices aim at interrupting one or both of these two steps.

Sheet erosion - Sheet erosion is defined as the uniform removal of soil from an area by raindrop splashing and water runoff. Water channels are developed but do not exceed approximately 12 inches in depth. Water moves across the field surface at a very shallow depth, and the soil is removed in thin layers and sheets. When sheet erosion occurs, the soil is removed in such thin layers that it is often unnoticed.

Rill erosion - This type of erosion forms small, well-defined incisions which are less than 12 inches in depth. These incisions or small channels occur primarily in recently tilled fields. The management factors causing excessive sheet and rill erosion are: cultivation of unsuitable lands (Classes V-VIII), not using a conservation cropping system (such as crop rotation), farming row crops with the slope, not maintaining good residue cover and using improper tillage methods.

Gully erosion - Severe erosion occurs where trenches are incised to a depth greater than 12 inches. In general, ditches which are deep enough to be difficult to cross with farm machinery are considered gullies. These gullies can range from a depth of 1-100 feet. Gullies develop where steep, erodible land has been farmed. Gullies also develop when water concentrates in areas where the vegetative cover has been disturbed, such as livestock trails, farm roads or plow furrows. In other words, when the velocity of water exceeds the ability of soil and soil cover to withstand erosion, gullies develop.

**Wind erosion** occurs in areas of high prevailing wind speeds and low annual rainfall. Fine, sandy soils on wide, flat, smooth fields are the most susceptible. Many of Missouri's loess (windblown) soils were blown to Missouri from northern regions thousands of years ago. Wind erosion is less of a problem in Missouri than water erosion due to Missouri's adequate rainfall and topography. It is more prevalent in plains states such as Texas and Oklahoma.

**Geological vs. Accelerated Erosion**

Geological erosion is that which occurs naturally or without the influence of man. It is an aspect of the constant process of change in the physical pattern of the surface of the earth. Geological erosion includes not only the displacement or erosion of soil but the process of soil formation from the gradual breakdown of rock. The formation of one inch of the kind of topsoil needed for good agriculture takes 150-1,000 years under the best of conditions. And the formation of the 5-10 inches of topsoil needed to grow field crops requires many generations.

Accelerated erosion is the erosion process influenced by man. On a world scale, man's non-agricultural activities which accelerate erosion are hardly significant. On the other hand, agriculture is so widespread that agricultural activities are the major cause of accelerated erosion. Nearly all traditional agricultural practices tend to encourage erosion. Soil conservation, then, is the attempt to control needless erosion.

**Missouri Soils Lost to Erosion**

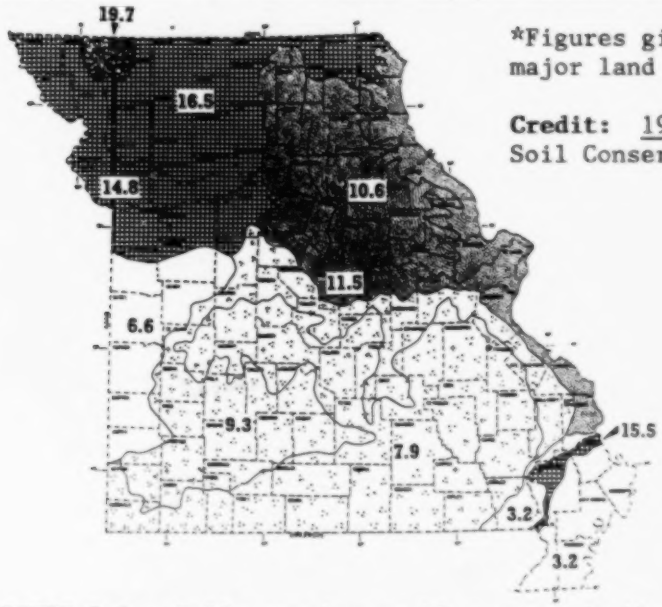
Sheet and rill erosion are major problems on croplands in Missouri. The average allowable soil loss for Missouri soils has been estimated at 3-5 tons per acre. The 1982 National Resource Inventory reported an average soil loss in Missouri of 11 tons per acre. Only three other states have average annual soil loss from croplands exceeding 10 tons per acre.

While such losses are excessive, they are often undetected or unnoticed by landowners or operators. It is very difficult to visually notice this loss soon enough, as a loss of **five tons per acre is about the thickness of an average sheet of paper.** Approximately 15 tons per acre is the minimum soil loss that can be seen. Even though 55-95% of total sediment loss comes from sheet and rill erosion, the seriousness of such erosion is often overlooked.

Figure 3.1 shows average annual erosion for cultivated cropland throughout Missouri. The data shows that sheet and rill erosion exceeds the allowable limits in every major area of the state. In much of Missouri's better crop-

land, annual losses are 15-20 tons per acre. Soils vary in weight, but for the average soil 20 tons per acre amounts to about 1/8 of an inch. In a short amount of time, this loss will have a significant impact on crop production.

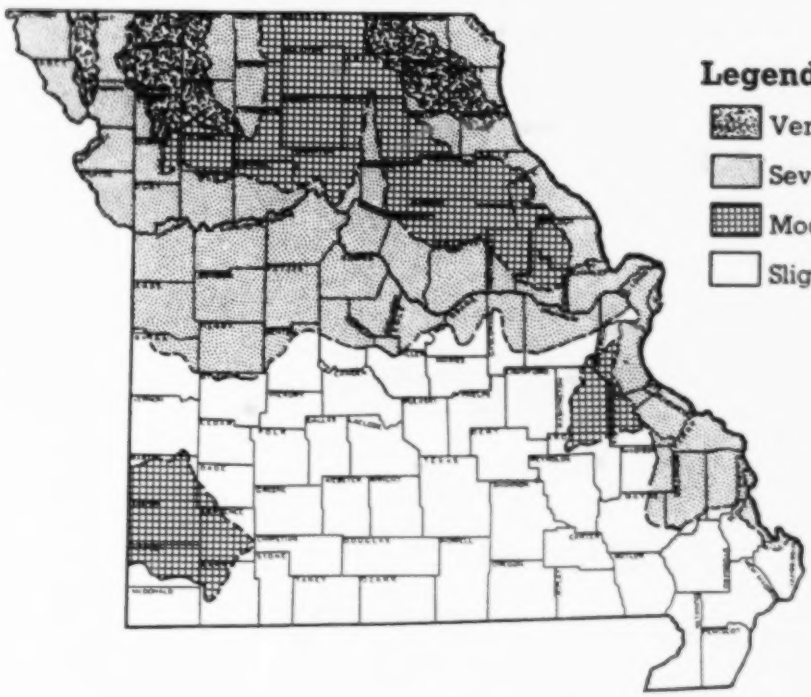
FIGURE 3.1 - Average annual erosion* (tons per acre)




*Figures given for cultivated cropland by major land resource area.

**Credit:** 1982 National Resource Inventory. Soil Conservation Service, USDA.

FIGURE 3.2 - Gully erosion problem areas in Missouri




**Credit:** Best Management Practices (Manual 117). Columbia: University of Missouri Extension Division and Missouri Department of Natural Resources, 1980.

Missouri's pastureland and rangeland lose much less soil than croplands and were within allowable limits, according to 1982 statistics.

Figure 3.2 shows the severity of gully erosion problems by basins in Missouri. The very severe gully erosion is given as a range of 500-750 tons per square mile. A 1978 joint agency report in Missouri shows that large areas of northwest Missouri have gully erosion ranges as high as 2,000 tons per square mile.

**Summary**

The formation of one inch of topsoil needed to grow crops can take 150-1,000 years. The erosion process takes place naturally but can also be influenced by man. Agriculture is the major cause of accelerated erosion. In Missouri, water is the most destructive force, causing sheet, rill and gully erosion. Conservation practices are aimed at choosing management techniques that positively affect the erodibility of the soil.

**Credits**

Bosworth, Duane A., and Albert B. Foster. Approved Practices in Soil Conservation. Danville, Ill.: Interstate Printers and Publishers, Inc., 1982.

Hudson, Norman. Soil Conservation. Ithaca, NY: Cornell University Press, 1981.

UMC Extension Division publications

a) M117: Best Management Practices for Erosion and Sediment Control
b) MX121: Conservation Tillage: Considerations for Missouri Farmers
c) MX101: Impact of Continued Soil Erosion

UNIT - SOIL CONSERVATION

Lesson 4: Cropping and Reduced Tillage Systems

No single soil conservation practice is designed to meet the needs of all farms. It may take only one practice--or as many as five--to effectively control erosion. Knowing what practices exist and how they can benefit the farming operation will help the farmer design the best soil conservation program.

Conservation tillage refers to any tilling operation sequence that retains at least 30% residue cover on the soil surface after planting. Conventional tillage generally includes moldboard plowing, several disking and smoothing operations and at least one cultivation.

**Reduced Tillage**

This practice eliminates one or more tillage operations from a conventional tillage program. Reduced tillage is a component of a conservation cropping system as it reduces soil loss. It has a number of important functions.

1. Retards the deterioration of soil structure
2. Reduces soil compaction and the formation of tillage pans
3. Improves soil aeration, permeability and soil condition
4. Controls erosion
5. Requires less fuel and labor
6. Provides wildlife with more food and cover during the winter

Chisel plant - This method prepares the seedbed by using a chisel plow or field cultivator. The soil is broken up or loosened without being inverted. Most of the crop residue remains on or near the surface to control erosion. Chisel planting can greatly reduce the erosion over conventional tillage if adequate residue remains. The amount of soil loss reduction will depend on the pounds of residue left on the surface after planting.

Strip till - The strip till method disturbs only a narrow strip of soil to provide a good seedbed for the crop that is being planted. This is generally done with a small section of rotary hoe for each crop row. Any additional tillage is for weed control. For some crops, such as cotton, this seedbed preparation is preferred.

Ridge-till - The seedbed is prepared by scalping the old crop row and its residue, pushing that residue into the interrow area. The new crop is planted in the scalped area, providing the seed a uniform, suitable seedbed. Clods and residue between the planted rows provide erosion protection.

No-till - Crops are planted without prior seedbed preparation into an existing cover crop, sod or crop residue. This system eliminates subsequent tillage operations. The next lesson is devoted to no-till farming.

TABLE 4.1 - Surface residue remaining after tillage operations*

| Tillage system | Percentage of residue from previous crop remaining on field surface | | | |
|---|---|---|---|---|
| | Corn | Soybeans | Small Grain | Sod |
| Moldboard plow, disk, field cultivate | 5 | 2 | 5 | 10 |
| Chisel (4" twisted points) | | | | |
| + disk twice | 15 | 2 | 10 | 20 |
| + disk once, field cultivate once | 20 | 5 | 15 | 25 |
| Chisel (2" straight points) | | | | |
| + disk twice | 20 | 5 | 15 | 25 |
| + disk once, field cultivate once | 30 | 10 | 25 | 30 |
| Primary tillage disk (deeper than 6") | | | | |
| + disk twice (standard tandem) | 10 | 5 | 15 | 20 |
| + disk once, field cultivate once | 20 | 10 | 20 | NA |
| Shallow disking (less than 6") | | | | |
| once (standard tandem) | 40 | 20 | 45 | 50 |
| twice (standard tandem) | 20 | 10 | 25 | 30 |
| Field cultivate once | NA | 30 | NA | NA |
| Ridge-till | 30 | 20 | NA | NA |
| In-row subsoil, plant | 70 | 50 | 80 | 85 |
| No-tillage plant | 80 | 60 | 90 | 95 |

*Variations of ±30% are common due to such factors as yield, soil condition, tillage speed and harvesting distribution of residue.

Credit: Griffith, Donald; Jerry Mannering; J. E. Box. "Soil and Moisture Management with Reduced Tillage," No-Tillage and Surface Tillage Agriculture: The Tillage Revolution. New York: John Wiley & Sons, Inc., copyright (c) 1986. Used by permission of John Wiley and Sons, Inc.

**Contour Farming**

Contour farming utilizes cultivated land so that all operations are done on the contour to reduce erosion and control runoff. Contouring becomes most

effective in reducing erosion and sediment when used in conjunction with other conservation measures such as terraces and contour strip cropping.

On flatter slopes of 2-8%, contour farming can help reduce soil loss by 50% over up-and-down-hill farming. (See Table 4.2.) While effective in reducing soil loss from sheet erosion, gullying may occur as water follows the furrows during heavy rains and concentrates in low areas. For this reason it is often advisable to use terraces, grass waterways, strip cropping or a combination of these with contour farming. Terraces and grassed waterways will be discussed in Lesson 6.

TABLE 4.2 - Soil loss by contour farming

| | Max. slope length | | |
|---|---|---|---|
| % slope | <50% cover | >50% cover | Reduction |
| 1-2% | 400 ft. | 500 ft. | 40% |
| 3-5% | 300 ft. | 375 ft. | 50% |
| 6-8% | 200 ft. | 250 ft. | 50% |
| 9-12% | 120 ft. | 150 ft. | 40% |
| 13-16% | 80 ft. | 100 ft. | 30% |
| 17-20% | 60 ft. | 75 ft. | 20% |

Credit: "Standards and Specifications for Contour Farming." Soil Conservation Service.

**Strip Cropping**

Strip cropping is a systematic arrangement of crops planted in strips to reduce erosion. The crops are arranged so that a strip of grass, small grain or other close-growing crop is alternated with a strip of clean tilled or row crop. The purpose of strip cropping is to reduce erosion by controlling surface water runoff. The strip of close-growing crop acts as a filter to reduce the sediment loss from the intervening clean tilled or row crop area.

Strip cropping is beneficial to wildlife by creating a variety of crops in close proximity to each other. Wildlife species have a better chance of finding their habitat requirements with increased crop diversity.

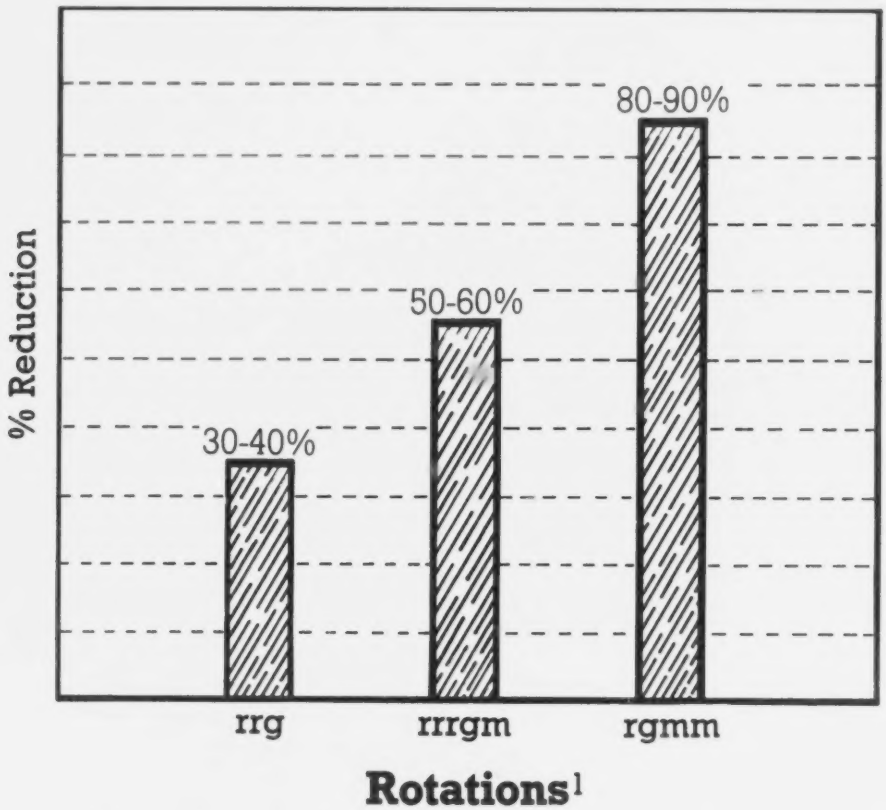
**Crop Rotation**

Crop rotation involves growing crops on the same land in an orderly sequence, including row crops, grasses and legumes. Crop rotation provides soil cover to help reduce erosion. Rotation can improve soil fertility, increase soil moisture and help reduce pest problems. Decreased pesticide usage lowers the threat of wildlife consuming chemically killed insects and rodents. The amount of erosion reduction from common rotations is shown in Fig. 4.1.

Soil loss from a field with good grass or legume cover is very small. When sod or legume is plowed under, the residue helps improve water absorption and retention capacity of the soil and reduce the erodibility of the soil. These

effects are substantial the first year following plowing and remain significant during the second year.

FIGURE 4.1 - Effects of rotation on erosion reduction




[1] r = row crops such as corn, soybean
g = small grain such as wheat
m = meadow or hayland

**Credit:** Best Management Practices (Manual 117). Columbia: UMC Extension Division and Missouri Department of Natural Resources, 1980.

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A crop rotation that does not include a grass or legume is generally a rotation of two kinds of row crop or a row crop and a small grain. The selection of the crops, cropping sequence and tillage methods--to increase residue--is very important in reducing erosion.

**Summary**

There are many cropping and tillage systems which can be used alone or in combination to aid in reducing soil loss and increasing land productivity in the farming operation.

**Credits**

UMC Extension Division publications

a) M117: Best Management Practices for Erosion and Sediment Control
b) MX102: Soil Erosion Control Practices

"Soil Conservation Systems for Missouri." Missouri Association of Soil and Water Conservation, 1983.

UNIT - SOIL CONSERVATION

Lesson 5: No-Till Farming

No-till farming takes a different approach to the basic task of planting and tending crops. The no-till concept challenges many practices that farmers have believed in and followed for generations. Some farmers have said no-till is as much a "change in farming philosophy" as it is a change in farming method.

**Benefits and Limitations of No-Till Farming**

No-till farmers are fond of proclaiming that this farming concept saves "soil, toil and oil."

Potential benefits - Reducing erosion by wind or water is one of the major benefits of no-till cropping systems. As discussed in Lesson 4, crop residues or sod cover can reduce soil erosion 90-95% over conventional tillage.

Conserving energy is another major benefit of no-till cropping systems. Tractor fuel is the largest single use of energy in agriculture. No-till farming conserves fuel simply by reducing the number of trips a farmer makes across a field with the tractor. The amount of fuel saved will vary from farm to farm due to such factors as the soil type, the size and type of tillage tools, the size and shape of the field, and the size of tractor. Many studies show no-till can use one-third the fuel that conventional tillage requires.

Saving time and labor is an additional benefit in no-till systems. Eliminating tillage obviously means decreasing the time required for each tillage operation. Many studies indicate that no-till farming reduces labor by 50-60% over conventional tillage, especially after the first few years of use. No-till can require fewer days to plant a crop. This labor reduction may be offset somewhat by increased management time.

Machinery costs may be reduced in a no-till system. A conventional tillage program may require eight or more pieces of equipment--moldboard or chisel plow, disk, rotary tiller, spring- or spike-tooth harrow, field cultivator, row-crop cultivator, planter, spray rig and tractor. No-till basic requirements for planting are a tractor, no-till planter and spray rig.

No-till farming may also allow the operator to farm with smaller or fewer tractors. No-till may cut power needs in half. Since no-till can save valuable time, doublecropping (harvesting two crops off one field in one year) is a practical option in many areas of the country.

Conserving soil moisture may be a farmer's most important concern when attempting the highest possible crop yield. No-till farming conserves soil moisture significantly for two major reasons. First, evaporation is reduced because the soil is not turned over and exposed to the sun's radiation. Plant tissue tends to shade the soil, causing lower soil temperatures and less

evaporation. Secondly, the sod, stubble or cover crop tends to trap water during a rain, giving it more time to soak into soils.

No-till farming helps wildlife by leaving waste grain and crop residue on the fields during the winter. The crop residue frequently plays a dual role by providing nesting habitat for ground-nesting birds in the spring.

Other benefits include increasing organic matter, improving soil structure, reducing crusting and providing firmer soil conditions at harvest. The crop residue frequently plays a dual role by providing nesting habitat for ground-nesting birds in the spring.

Potential limitations - More than two decades of research, field trials and practical farm experience have proven that no-till farming will work in most farming situations. But whether it is the best alternative in a particular situation is another matter. There are limitations to the no-till concept.

Management must be given careful consideration in no-till systems, especially in weed control. After planting, a no-till farmer may be able to correct an error in weed control by cultivating. Certain weed problems are particularly difficult and expensive to control with herbicides alone. Experienced no-till farmers often say no-till is not so much a matter of more management but a different type of management. Many recommend starting small with only 25-50% of the total acreage in no-till and expanding later as experience is gained.

Cooler soil temperatures may be an advantage in droughty periods, but they are a real problem in heavy, poorly drained soils. No-till is not recommended in such sites unless subsurface drainage systems are installed. Also, these cooler, wet soils can delay planting and reduce seed germination.

No-till requires careful monitoring for pest control. The main reason for this is the crop residue remaining on the soil surface throughout the year, which provides a suitable environment for insects and diseases. Residue causes cooler, wetter soils which encourage the development of many diseases that attack seeds and seedlings. Many insect life cycles and weed problems are controlled by plowing.

Pesticides are substituted for tillage in no-till planting. A no-till farmer spends more on pesticides than a conventional tillage farmer. Care must be taken to use pesticides according to label instructions to minimize potential environmental hazards. However, many contend the reduction of soil erosion will reduce non-point pollution. This reduction may actually result in fewer environmental hazards.

There are three types of pesticides used in no-till: herbicides, insecticides and fungicides. Herbicides, the largest category, are used for burn-down, pre-plant and post-applied applications. Burn-down chemicals include 2-4 DB, Round-Up, Paraquat and Bronco. Some pre-plant herbicides are Lorox, Sencor and Lasso. Post-applied chemicals include Basagran, Blazer, Tackle, Cobra, Scepter and Classic.

No-till may have an overall positive effect on wildlife populations. However, early ground-nesting birds may have their nests destroyed by planting operations or by application of agricultural chemicals.

**Crops Grown in No-Till Systems**

Corn - The first crop to be no-tilled on a large-scale basis, corn still ranks as the major no-till crop, accounting for about one-third of the total U.S. no-till acreage. No-till corn may be planted in killed sod, cover crops or previous crop stubble. Continuous corn may be grown successfully with no-till, but most growers rotate corn with other crops, such as legumes or small grains. This practice helps control weeds, insects and diseases, while improving general soil condition. Also, rotations with nitrogen-fixing legumes put back some nitrogen removed by corn.

Soybeans - This crop ranks closely behind corn in terms of total no-till acres and may soon replace corn as the No. 1 no-till crop. There are basically two types of no-till soybean programs.

1. Singlecropping: Full-season no-till soybeans may be planted into small grain cover crops or previous crop residue.
2. Doublecropping: Planting soybeans behind small grains is one area in which no-till really excels. It offers two major benefits. First, time and labor are saved as soybeans may be planted soon after small grain harvest. Second, soybeans need ample moisture to germinate, and moisture is often short after small grains are harvested. Tillage compounds this problem. Left intact in no-till, small grain stubble has a mulching effect on young soybean seedlings, which conserves moisture.

Grain sorghum - This crop is frequently grown by no-till methods behind small grains, either full-season or doublecropped. Production practices and benefits are largely the same as with soybeans; moisture is conserved and a longer growing season results because of earlier planting.

Alfalfa and other forage legumes - These can be seeded effectively into small grain stubble with a no-till drill. This system is compatible with the crop rotation used by many dairy and livestock producers. It allows harvest of both grain and straw crops for livestock uses, then alfalfa for hay production, and ultimately rotation to corn and small grains.

Pasture renovation - Millions of acres of permanent pastureland are not producing at near their potential. One reason has been the difficulty at renovating through traditional tillage techniques. Plowing and disking are often not feasible because of the expense involved, erosion hazard and obstacles in the pasture, such as rocks or trees.

No-till pasture renovation involves interseeding legumes or improved grass varieties into existing sod. The existing turf must be grazed or mowed very closely to control competition with new seedlings. Often a contact herbicide is used to suppress all or part of the sod and to kill weeds. The new seedlings then germinate without competition, and sprayed sod will recover within

30-60 days. This method works well when establishing legumes into fescue, bluegrass, orchardgrass and similar forages.

Small grains - Winter-seeded small grains such as wheat, barley, oats and rye are perhaps the easiest of all crops to no-till. Using a no-till drill, small grains may be planted into previous crop stubble or pasture that has been killed with a contact herbicide. Avoid planting by no-till into fields infested with hard-to-control perennials. If planting into heavy crop residue such as corn stalks, it is advisable to chop the stalks before planting, spreading the residue as evenly as possible.

**No-till Planters and Drills**

Every brand of no-till planter is different in some respect, but in general a no-till planter must fulfill certain requirements.

1. Must be heavy enough to cut through previous crop residues or sod without excessive problems
2. Must provide a narrow band of tilled soil for receiving seed
3. Must plant seed at a preselected, uniform depth (1-3 inches). Crop, soil temperature and depth to adequate moisture will dictate the depth of seed placement.
4. Must cover and firm soil around seed. Seed coverage is normally accomplished by a press wheel, or small disks, behind the seeding unit. Seed coverage is necessary for germination and to provide protection from bird and rodent damage. Firming the soil in the row reduces air pockets, establishes good seed-soil contact and maintains desirable moisture conditions for germination.
5. Must measure distance accurately at a wide variety of seeding rate adjustment settings
6. Must have row width flexibility for different crops and seasonal conditions

Despite brand variances, no-till planters have a number of vital parts in common. A description of those parts follows.

Coulters - Coulters cut through stubble, residue or sod, allowing seed openers and press wheels to function properly. One of three basic coulters is typically used: smooth, fluted (1-inch or 2-inch) or rippled (Fig. 5.1). Smooth coulters are best used when planting forages or small grains or when cutting residues in front of other soil-opening devices. Wide-fluted coulters till a sizable slot, which allows seed openers and press wheels to operate in conditions similar to conventional tillage. However, these wide coulters have some disadvantages. If soils are wet, hard, sod-bound or if the planter is being operated too rapidly, the coulter often throws the soil away from the slot, resulting in poor depth control and poor seed-soil contact. The narrow-fluted or ripple coulter is generally the preferred type for most soil conditions.

Coulters should be adjustable three ways: vertically, horizontally and in the distance from seed openers. Generally, coulter depth is set 1/4-1/2 inch deeper than the intended seeding depth. Side-to-side movement allows for

proper alignment with the planter row unit. When contour farming, the coulter placement to seed opener is important. If coulters are placed more than 1-2 feet in front of seed openers, the openers may not stay in the slot when planting. If coulters are closer than 4-6 inches to seed openers, trash or rocks may jam between the coulters and seed openers.

FIGURE 5.1 - Coulter types

From left: smooth, ripple or narrow fluted, and wide fluted.

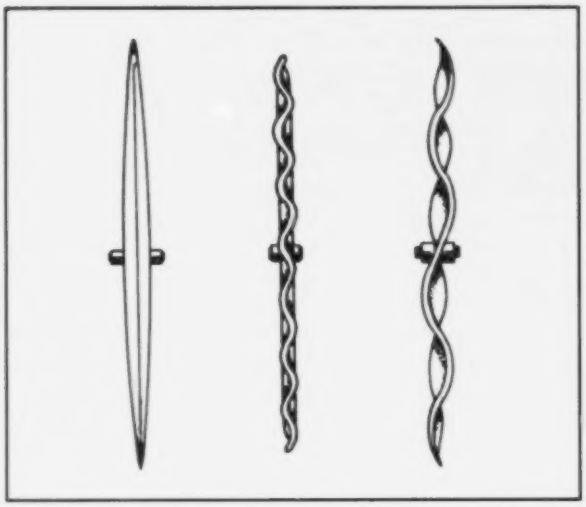
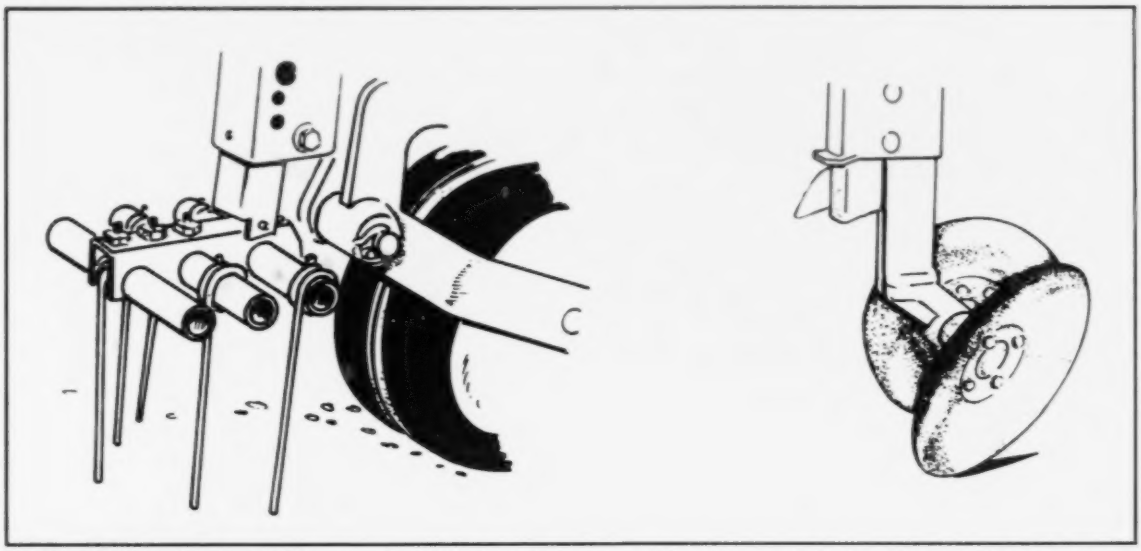


FIGURE 5.2 - Residue moving devices

Rake tines and V-shaped discs.



**Credit:** Helsel, Zane R., et. al. "No-Till Planting Systems." Columbia: UMC Extension Division. Agricultural Guide 4080, 1983.

Residue-moving devices - Heavy or wet residue often keeps planters from functioning properly by binding planter units or causing seed units not to plant to uniform depth. Several devices have been developed to solve these problems. The first, a smooth coulter which normally cuts through residue, is placed in front of the fluted or rippled coulter. The first coulter cuts residue as the second forms a slot.

Two other devices have been developed to move residue (Fig. 5.2). Rake tines drag along the soil surface creating a vibrating action which keeps short, light residue (chopped wheat straw) out of coulter or seed opener paths. But with long, heavy residue (corn stalks), this device may only drag. V-shaped disks are also used to remove residue. When placed in front of coulters, these disks cut residue and move it to the side.

Seed openers - These devices open a seed furrow behind the coulter. There are three types of seed openers: single or double disk, shank and slot. Most no-till farmers have best results with double disk openers.

Press wheels - Ensuring proper seed-soil contact is the primary function of press wheels. Not all press wheels that work effectively in conventional tillage work in no-till conditions. Small dolly wheels or covering disks can be used to place or firm soil in the seedbed. To solve seed coverage problems, added weight over coulters (400 lbs. per row), spring down pressure or reduced driving speeds will allow for proper seed-soil contact.

Other features - Many planters are set up to apply fertilizers, some granular insecticides and seed all in one pass. Other types of no-till planting equipment includes pasture renovation drills, heavy residue cultivators and no-till anhydrous applicators.

**Choosing a No-Till Planter**

No-till planters are more expensive than conventional tillage planters, and it is important to choose one wisely. Some steps a buyer should take before making a decision follow.

Particular needs - Which crops will be grown? Is a multipurpose or single-purpose planter needed? Consider the soil type and farming method, also.

Size needed - No-till planters are available in 2-16 or more rows. No-till planting is slower than conventional planting, so if many acres are being farmed, a bigger planter will be needed. A large planter requires careful monitoring to make sure each row is performing properly. If fields are rough, hilly or irregularly shaped, a 4- to 6-row planter may perform better. Consider, too, the horsepower of the tractor to be used. As a rule of thumb, no-till planters require 8-10 hp per row.

The marketplace - Farm equipment dealers, other farmers, county extension agents or Soil Conservation Service representatives can be valuable sources of information on suitable equipment.

Experimentation - If possible, take a planter to the field for a trial run.

Price and availability - Price is important, of course, but not as important as reliability and proven performance. Every type of farm equipment needs maintenance and repair, so make sure parts are readily available.

**Operating No-Till Planters**

No-till planters save time in every respect but one: planting. Operating a no-till planter requires slower driving speeds, attention to detail and frequent checking to make sure everything is performing properly. Here are some guidelines to follow when no-till planting.

Plan ahead - Make sure the planter is properly adjusted and ready to go when weather and soil conditions are right.

Check conditions - Plant when ground is dry enough. Care must be taken to ensure that the seed slot closes around the seed. Straw residues should be dry for best coulter results.

Check soil temperature - Measure at a 4-inch depth at 8 a.m. before planting. The minimum temperature for planting corn is 50F; for soybeans, 55F; and for grain sorghum, 60F. Forages and small grains may be planted in cooler soils.

Adjust planter - Set seed depth at 1 1/2 inches for corn and 1 inch for soybeans when planting early or in moist conditions.

Check fertilizer placement - If row placement of fertilizers is used, fertilizer should be placed away from the seed so it won't interfere with germination and emergence. Fertilizer is often placed 1-2 inches below and to the side of seed.

Check seeding rate - Check planter operating manual for proper setting for seeding rate desired, then check seed drop manually by operating planter at planting speed and measuring distance between seed. It is advisable to increase the seeding rate 10% over the conventional tillage rate.

Adjust planter weight - Weigh the planter, if necessary, to maintain an even planting depth (400-600 lbs. per row may be required). Weight over the rear tool bar may be most effective.

Watch operating speed - Normally plant at 3-4 mph (in contrast to 4-6 mph for conventional tillage). If coulters are throwing soil out of the rows, decrease speed.

Check planter operation - Stop in the field to check seed placement depth and spacing, alignment of coulters and proper fertilizer placement. Make this check in low spots and knobs, as well as on level ground.

Fertility tips - Where practical, test the soil in fields planned for no-till systems that are under conventional tillage. Bring them up to medium- or high-test levels. Incorporate fertilizer and lime uniformly. If done before planting, crop production can be maintained with topdressed lime and fertilizer application.

The pH in the top few inches of the soil may decrease in a no-till field when nitrogen fertilizers are applied to the surface. This acidified layer limits root growth, nutrient availability and herbicide activity. Frequent applications of small amounts of lime will correct the problem.

Take soil test samples for pH in the upper two inches to determine when surface acidity problems exist. Use standard 6- to 7-inch soil samples for nutrient requirements. If only the surface 2-3 inches of soil requires lime, apply only one-half of the lime recommendation given on a soil test report for the surface soil sampling.

Avoid over-liming or liming just before planting, particularly if using triazine herbicides. High pH increases the activity of these herbicides, which can cause crop injury.

In no-till cropping systems, more nitrogen is lost when applied to the surface than when incorporated or injected into the soil. If nitrogen must be applied to the surface, increase the recommended rates for conventional tillage by 15%.

Take soil test samples for phosphate and potash at a 6- to 7-inch depth on no-till fields. Direct-inject applications are beneficial in no-till conditions to move phosphate and potash into the root zone. The rates recommended by the soil test report are the same for no-till as conventional till.

**Summary**

No-till cropping systems can have many benefits to the farming operation. No-till is one of the most effective controls for soil erosion as well as saving time, fuel and labor. It is important, however, to recognize the limitations when deciding on its possible use in an operation.

Important considerations for no-till success include choosing the right combination of crops, the appropriate machinery, proper fertility, judicious control of pests and diseases, and proper planting techniques.

**Credits**

UMC Extension Division agricultural guides

a) 4080: No-Till Planting Systems
b) 4906: Soil Insect Pest Control in Reduced Tillage Cropping Systems

Fundamentals of No-Till Farming. Athens, Ga: American Association for Vocational Instructional Materials, 1983.

Helsel, Zane R. "Conservation Tillage Tips #2." Columbia: UMC Extension Division and Soil Conservation Service, 1984.

UNIT - SOIL CONSERVATION

Lesson 6: Erosion Control Structures

Many structures can be used to help combat soil erosion by interfering in the second step of the soil erosion process by water: the transportation of soil particles. These structures, as part of a resource management system, help reduce the velocity of overland water flow, thereby diminishing the ability of water to transport soil off the field.

**Terraces**

A terrace is an earth embankment, channel or a combination ridge and channel, constructed across the slope to decrease slope length and control runoff. Runoff from terraces may be diverted into grassed waterways or through underground conduits such as tile or plastic drain tubing.

Terraces serve several useful purposes. They reduce erosion, reduce sediment content in runoff, intercept and conduct surface runoff at a non-erosive velocity to a stable outlet, retain runoff for moisture conservation, prevent gully development and reduce flooding.

Consider building terraces when there is a need to conserve water or there is an erosion problem and contouring alone is inadequate. Terraces can help when runoff and sediment is impairing water quality or damaging land, streams or improvements. A suitable outlet for the terrace is needed, and the soils and topography should allow for construction and farming with reasonable cost and effort.

**Terrace Outlets**

When surface flow and runoff occur, the terrace intercepts water and carries it at a non-erosive velocity to the **grassed waterway** (Figure 6.1). The grass waterway must have a suitable grade and sufficient capacity so that the grass can be properly maintained. Steep land may cause water velocities so rapid that vegetation no longer protects the channel, necessitating control structures.

Terraces with **underground outlets** store runoff water in the terrace channel for a short period of time. Runoff is then removed through an underground conduit, sometimes referred to as a tile outlet (Figure 6.2). The terrace should be able to handle runoff from an intense storm without overtopping the terrace ridge. Underground outlets promote the parallel alignment of terraces and eliminate the need for grassed waterways, making more land available for cropping. The installation cost is generally higher, but maintenance should be somewhat less.

Some terraces are used without outlets. In northwest Missouri, level terraces work on the principal that water is stored for a period of time and then infiltrates into the ground. The soil must have a rapid absorption rate for this type of terrace.

FIGURE 6.1 - Grassed waterway

Gradient terraces with a grassed waterway outlet.

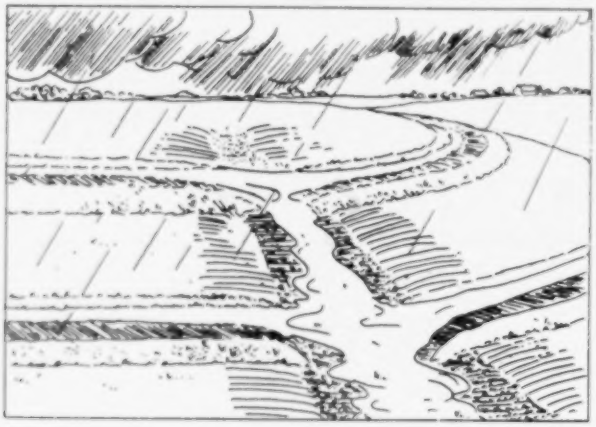


FIGURE 6.2 - Underground outlet

A gradient terrace with an underground outlet. The inlet at each terrace is restricted to keep the pipe from flowing full and discharging water into the terraces at the lower end of the slope. Plastic pipe is generally used for the underground conduit.

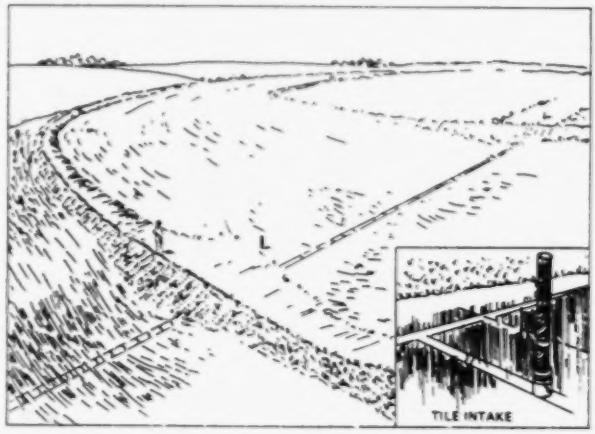
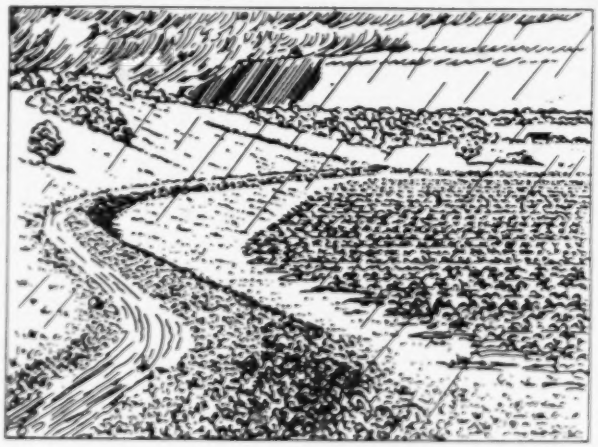



FIGURE 6.3 - Diversion

A diversion being used to intercept hillside runoff to protect cropland at the base of the hill from erosion, sediment and flood damage.



**Credit:** Best Management Practices (Manual 117). Columbia: UMC Extension Division and Missouri Department of Natural Resources, 1980.

**Types of Terraces**

The three main types of terraces are broad base, narrow base and steep backslope. Each kind has its own set of pluses and minuses that are dependent on the individual situation. When considering terrace construction, the land user should carefully weigh the advantages and disadvantages of each type of terrace.

Broad base - There are several advantages to broad base terraces. The entire terrace can be farmed, so no land is taken out of crop production. Less earthfill is needed for construction when land slopes are uniform. Moldboard plows may be used to maintain ridge height. The ridge is easier to construct because soil is pushed down the hill. Broad base terraces are adapted to flatter landslopes of less than 8%.

There are, however, disadvantages to broad base terraces. The final landslope between terraces is steeper than the original landslope. Terraces are more difficult and hazardous to farm, and more field area is disturbed during construction. Parallel alignment may be difficult and more costly to construct on irregular land.

Steep backslope - This type of terrace has advantages and disadvantages, as well. On the positive side, the final landslope between terraces is flatter than the original landslope. Grassed backslopes provide food and cover for wildlife. Terraces are easier to make parallel to each other and can be adapted to steeper landslopes of greater than 8%.

On the negative side, a steep backslope terrace is seeded with grass and removed from crop production. It may require periodic control of weeds and burrowing animals. Care must be taken when operating equipment near the steep backslope. High ridges may limit access within the field. Special care needs to be used when applying herbicides next to vegetated slopes.

Narrow base - Less earthfill is needed for the narrow base terrace, and less field area is disturbed during construction. The final landslope between terraces is flatter than original landslope, and inlet pipes do not interfere with farming operations. Vegetation on the entire ridge provides food and cover for wildlife. Machinery does not operate on or near a steep ridge. This type of terrace is adapted to landslopes of less than 15%.

However, narrow base terraces remove the entire terrace ridge from crop production. The ridge may require periodic control of weeds and burrowing animals, and access may be limited within the field. Sediment may need to be periodically removed from the terrace channel. Special care needs to be used when applying herbicides next to vegetated slopes.

**Diversions**

A diversion is a channel with a supporting ridge on the lower side constructed across the slope to divert water at a nonerosive velocity to sites where it can be used or disposed of through a stable outlet.

Diversions are constructed for many reasons. They divert water from erosion-prone areas and can also move polluted water to a satisfactory disposal area or facility, sometimes serving as a sediment trap.

Diversions should not be used below high sediment-producing areas unless provisions have been made to accommodate the rapid sediment accumulation or to bring the sediment-producing area under control by other means.

Consider diversion construction when runoff from higher lying areas is damaging cropland, pastureland, farmsteads or other conservation practices, such as terraces or strip cropping. Diversions can divert runoff for two purposes: to control erosion and to reroute runoff to areas where it is needed, such as drainage areas above a pond to ensure adequate water supply.

**Grassed Waterways**

There are two main types of grassed waterway outlets: natural watercourse and field boundary waterways.

Natural watercourses - These outlets may be natural, well-vegetated draws or natural watercourses that need to be shaped or enlarged to handle the combined flow of the terraces or diversions.

There are several advantages to this type of outlet. They are generally the flattest grade in the immediate area. Grassed waterways, especially in the case of natural, well-vegetated draws, are often ready for immediate use. With grassed waterways, terraces are easier to parallel to avoid point rows. Sufficient depth is available to permit easy outletting of terraces, diversions and contour rows. They may require less earth movement to provide adequate channel capacity. With grassed waterways, terraces may be kept shorter and terrace channel grades less critical.

Grass waterways provide valuable wildlife nesting sites, particularly if tall fescue is not used. To increase nest survival, delay mowing until August.

There are also some disadvantages to be considered. Waterways are often crossed during farming operations, which increases the need for maintenance. Generally, more problems develop in maintaining grass areas due to chemical damage from spraying operations. Grassed waterways may make equipment travel around the farm more difficult. If waterways cannot be crossed with farm equipment, the field will be separated into smaller tracts.

Field boundary waterways - These watercourses are constructed adjacent to a field boundary and are infrequently used for several reasons. Sharp turns in the terrace systems are needed for outletting into the waterway. Field boundary waterways are impractical for use with large, modern equipment. They tend to create unnatural water flow, require greater earth movement and often require steeper waterway grades.

Some advantages of field boundary waterways include: (1) they can be located opposite from travelways and entrances, (2) maintenance is reduced since the

waterway is not crossed with equipment, and (3) accessibility from the farmstead can be more easily obtained.

**Gully Stabilizing Structures**

A gully stabilizing structure is used to stabilize the grade or to control gully head erosion into a natural or artificially stable channel. Its purpose is to prevent the development or advancement of gully heads due to the concentration and flow velocity of water in the channel. These structures may range from small metal or wooden drops to sizable concrete structures, up to 30-40 feet high, or to large earthen fills, depending on the site requirements. The type of structure used will depend on the amount of grade that must be controlled, size of the drainage area and site conditions.

Straight drop spillway - Sometimes referred to as a weir drop structure, the straight drop spillway diverts water through the opening and drops to the apron at the downstream channel level. The drop spillway is an efficient structure for controlling drops of up to 10 feet. It is more commonly used where the drop does not exceed 5-6 feet. This stable structure tends to remain free of debris. It is well-suited to sites that require large flow capacity with little available storage and may be constructed of reinforced concrete, concrete blocks, prefabricated metal or wood.

Drop inlet spillway - This type uses a vertical pipe inlet connected to a horizontal pipe through an embankment of an earth fill dam. The drop inlet is a very efficient structure for controlling relatively deep gullies. Through the use of temporary storage, this structure can reduce the peak channel flow and is economical to construct.

Hood or canopy inlet spillway - In this structure, a pipe is placed horizontally through the earth fill similar to the drop inlet except that there is no vertical pipe section. The inlet end of the pipe is placed with the hood canopy on top and the lower edge at the desired water level in the reservoir. The pipe is inexpensive and simple to fabricate and install. Its advantage over the drop inlet is that no vertical riser is required and there is less fill over the pipe.

Drop inlets and hood or canopy inlets are used in conjunction with earth fill dams. Many have been constructed in Missouri. They are adapted to any gully or valley site where the soils are suitable for good fill construction, storage is provided in proportion to the size of the drainage area and an economical structure is desired.

**Summary**

Structures often used to combat erosion in Missouri include terraces, used to decrease slope length and control runoff; diversions, used to divert erosive runoff or sediment to less damaging sites; grassed waterways, watercourse outlets used for the removal or disposal of runoff; and gully stabilizing structures, used to control gully head erosion into a stable channel. These structures are effective in reducing the transport of valuable topsoil. Used in conjunction with conservation cropping and tillage practices, these struc-

tures can effectively preserve valuable topsoil and enhance wildlife populations.

**Credits**

Hudson, Norman. Soil Conservation. Ithaca, NY: Cornell University Press, 1981.

Bosworth, Duane A. and Foster, Albert B. Approved Practices in Soil Conservation. Danville, Ill.: Interstate, 1982.

"Selecting a Terrace." Soil Conservation Service, USDA.

Best Management Practices for Erosion and Sediment Control (Manual 117). Columbia: UMC Extension Division and Missouri Department of Natural Resources, 1980.

UNIT - SOIL CONSERVATION

Lesson 7: Universal Soil Loss Equation

While it is not possible to eliminate all soil losses, the selection of crops, crop sequence, tillage operations and conservation measures can hold soil to some acceptable level. Individual practices are basic elements in solving an erosion or water management problem, but the practices may not solve the problems when applied individually. Experience has shown that a combination of practices may be required to control erosion.

Soil erosion varies throughout the state and from one field to another. There is often a great difference even within a single field. It is necessary, therefore, that some method be used to evaluate the various practices and the effect of their combined use to predict annual soil loss from an individual field or farm.

**Function of the Universal Soil Loss Equation (USLE)**

In order to plan and develop an effective erosion control program, many factors affecting erosion must be evaluated. The land user must be able to select a combination of agronomic and mechanical measures that are suitable to the needs and desired crops, and, at the same time, provide for a satisfactory level of erosion and sediment control.

The Universal Soil Loss Equation takes into account the variations in conditions such as rainfall, soil type, crop sequence, conservation practices and topography. This equation was developed by the agricultural research specialists from the United States Department of Agriculture. The USLE is recognized as an effective method of estimating soil erosion under various conditions. In Missouri, it is used by the Soil Conservation Service and the University of Missouri in developing soil conservation programs for individual land users.

**Limitations of the USLE**

The equation estimates long-term average annual soil loss for a specific situation. It will estimate soil losses from sheet and rill erosion but not from gully erosion. It is unusual for all the soil loss predicted by the equation to be transported from a field. Some soil is deposited in terrace channels, waterways or in flatter areas. The values calculated for soil loss are considered a rough estimate, but they are the best estimates available.

**Components of the USLE**

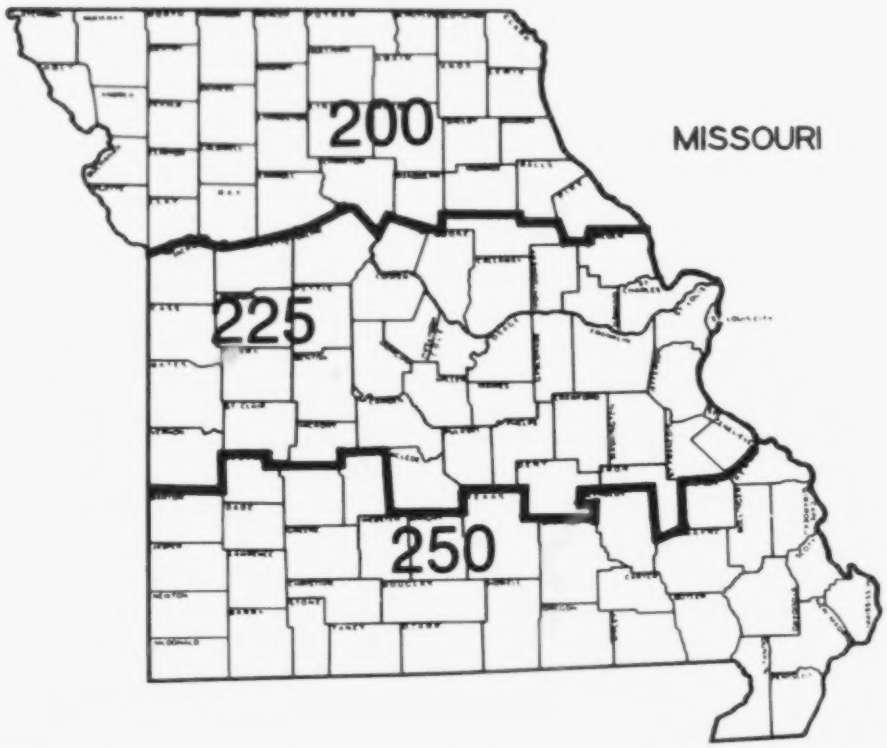
The Universal Soil Loss Equation and its components are as follows.

$$A = RxKxLSxCxP$$

A = estimated soil loss (tons/A/yr.)
R = rainfall factor
K = soil erodibility factor
LS = slope length, steepness factor
C = cropping management factor
P = erosion control practice factor

Rainfall (R) - This factor is a measure of rainfall energy rather than just rainfall. A short, intense four-inch rainstorm will cause much more erosion than a slow, steady four-inch rain. R factors shown in Figure 7.1 vary from about 200 in northern Missouri to 250 in southern Missouri, where intense thunderstorms are more common.

FIGURE 7.1 - Average annual values of the rainfall factor (R)




**Credit:** Steichen, James M. "Estimating Soil Losses in Northern Missouri" (G1560). Columbia: UMC Extension Division, 1979.

Soil erodibility (K) - Soil erodibility is a measure of the relative resistance to erosion of the soil itself. The larger the K value, the easier that particular soil will erode (see Table 7.1). Additional localized information can be obtained from SCS.

TABLE 7.1 - Erodibility (K) and erosion tolerance (T) factors

| | K | tons/ acre |
|---|---|---|
| Marshall - Knox - Napier<br>Deep loess soils adjacent to Missouri River bottom north and west of Glasgow | .32 | 5-4 |
| Sharpsburg - Grundy - Ladoga - Pershing<br>Moderately deep loess of west central Missouri | .37 | 3-2 |
| Adair - Shelby - Armstrong - Gara<br>Dark soil on slopes below loess deposits often used for forages and pasture | .28 | 3-2 |
| Mexico - Putnam<br>Claypan in northeast Missouri; level to moderately rolling | .40 | 3-2 |
| Menfro - Winfield - Weldon<br>River hills along Missouri River from central Missouri to St. Louis and Mississippi River hills north of St. Louis | .37 | 4-3 |
| Lindley - Keswick - Hatton<br>Sloping, less fertile soils of north central and northeast Missouri; pasture or timber | .37 | 3-2 |

Table 7.2 shows erodibility factor values for a broad grouping of several sloping upland soils. Generally, clay soils are more erodible than lighter sandy soils.

Slope length and steepness (LS) - Steepness and slope length are two important factors that affect erosion. A relative value of 1.0 has been assigned to a 9% slope with a length of 73 feet. The effects of slope steepness and length have been combined into LS values (Table 7.2). The average slope is estimated and found across the top of the table. The slope length (read on the side of the table) is the length from where flow begins to where sediment is deposited or where runoff enters a well-defined channel such as a terrace. For example, a 5% slope of 100 feet in length has an LS value of 0.6.

TABLE 7.2 - Slope length and steepness factor (LS)

| Length of Slope (L) (in feet) | Percent Slope (S) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 20 | * | .2 | .2 | .2 | .2 | .4 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.6 | 1.8 | 2.2 | 2.6 |
| 30 | .2 | .2 | .2 | .2 | .4 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.6 | 2.0 | 2.2 | 2.6 | 3.0 |
| 40 | .2 | .2 | .2 | .4 | .4 | .6 | .6 | .8 | .8 | 1.2 | 1.4 | 1.8 | 2.2 | 2.6 | 3.0 | 3.5 |
| 50 | .2 | .2 | .2 | .4 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.6 | 2.0 | 2.4 | 3.0 | 3.5 | 4.0 |
| 60 | .2 | .2 | .4 | .4 | .6 | .6 | .8 | 1.0 | 1.0 | 1.4 | 1.8 | 2.2 | 2.8 | 3.0 | 4.0 | 4.5 |
| 70 | .2 | .2 | .4 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.6 | 2.0 | 2.4 | 3.0 | 3.5 | 4.0 | 5.0 |
| 80 | .2 | .2 | .4 | .4 | .6 | .8 | .8 | 1.0 | 1.2 | 1.6 | 2.0 | 2.6 | 3.0 | 3.5 | 4.5 | 5.0 |
| 90 | .2 | .2 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.2 | 1.8 | 2.2 | 2.8 | 3.5 | 4.0 | 4.5 | 5.5 |
| 100 | .2 | .4 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.8 | 2.4 | 2.8 | 3.5 | 4.0 | 5.0 | 5.5 |
| 110 | .2 | .4 | .4 | .6 | .8 | .8 | 1.0 | 1.2 | 1.4 | 1.8 | 2.4 | 3.0 | 3.5 | 4.5 | 5.0 | 6.0 |
| 120 | .2 | .4 | .4 | .6 | .8 | .8 | 1.0 | 1.2 | 1.4 | 2.0 | 2.6 | 3.0 | 4.0 | 4.5 | 5.5 | 6.0 |
| 130 | .2 | .4 | .4 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.6 | 2.0 | 2.6 | 3.5 | 4.0 | 5.0 | 5.5 | 7 |
| 140 | .2 | .4 | .4 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.6 | 2.2 | 2.8 | 3.5 | 4.0 | 5.0 | 6.0 | 7 |
| 150 | .2 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.6 | 2.2 | 2.8 | 3.5 | 4.5 | 5.0 | 6.0 | 7 |
| 160 | .2 | .4 | .6 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.8 | 2.2 | 3.0 | 3.5 | 4.5 | 5.5 | 6.0 | 7 |
| 180 | .2 | .4 | .6 | .8 | .8 | 1.0 | 1.4 | 1.6 | 1.8 | 2.4 | 3.0 | 4.0 | 4.5 | 5.5 | 7 | 8 |
| 200 | .4 | .4 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.6 | 2.0 | 2.6 | 3.5 | 4.0 | 5.0 | 6.0 | 7 | 8 |
| 250 | .4 | .4 | .6 | .8 | 1.0 | 1.2 | 1.6 | 1.8 | 2.2 | 2.8 | 3.5 | 4.5 | 5.5 | 7 | 8 | 9 |
| 300 | .4 | .6 | .8 | 1.0 | 1.2 | 1.4 | 1.8 | 2.0 | 2.4 | 3.0 | 4.0 | 5.0 | 6.0 | 7 | 9 | 10 |
| 350 | .4 | .6 | .8 | 1.0 | 1.2 | 1.6 | 1.8 | 2.2 | 2.6 | 3.5 | 4.5 | 5.5 | 7 | 8 | 9 | 11 |
| 400 | .4 | .6 | .8 | 1.0 | 1.4 | 1.6 | 2.0 | 2.4 | 2.8 | 3.5 | 4.5 | 5.5 | 7 | 8 | 10 | 11 |
| 500 | .4 | .6 | 1.0 | 1.2 | 1.4 | 1.8 | 2.2 | 2.6 | 3.0 | 4.0 | 5.0 | 6.0 | 8 | 9 | 11 | 13 |
| 600 | .6 | .8 | 1.0 | 1.4 | 1.6 | 2.0 | 2.4 | 2.8 | 3.5 | 4.5 | 5.5 | 7 | 9 | 10 | 12 | 14 |
| 700 | .6 | .8 | 1.0 | 1.4 | 1.8 | 2.2 | 2.6 | 3.0 | 3.5 | 5.0 | 6.0 | 8 | 9 | 11 | 13 | 15 |
| 800 | .6 | .8 | 1.2 | 1.6 | 1.8 | 2.4 | 2.8 | 3.5 | 4.0 | 5.0 | 7 | 8 | 10 | 12 | 14 | 16 |
| 900 | .6 | 1.0 | 1.2 | 1.6 | 2.0 | 2.4 | 3.0 | 3.5 | 4.0 | 5.5 | 7 | 9 | 10 | 13 | 15 | 17 |
| 1000 | .6 | 1.0 | 1.2 | 1.6 | 2.2 | 2.6 | 3.0 | 3.5 | 4.5 | 5.5 | 7 | 9 | 11 | 13 | 16 | 18 |
| 1200 | .8 | 1.0 | 1.4 | 1.8 | 2.4 | 2.8 | 3.5 | 4.0 | 4.5 | 6.0 | 8 | 10 | 12 | 14 | 17 | 20 |
| 1400 | .8 | 1.2 | 1.6 | 2.0 | 2.4 | 3.0 | 3.5 | 4.5 | 5.0 | 7 | 9 | 11 | 13 | 16 | 18 | 21 |
| 1600 | .8 | 1.2 | 1.6 | 2.2 | 2.6 | 3.5 | 4.0 | 4.5 | 5.5 | 7 | 9 | 11 | 14 | 17 | 20 | 23 |

Contour Limits—2 percent 400 feet, 8 percent 200 feet, 10 percent 100 feet, 14-24 percent 60 feet. The effectiveness of contouring beyond these limits is speculative

Cropping management (C) - Vegetative cover, crop rotation, fertility level, tillage practices, crop residue management and related conditions have an important effect on erosion. All of the factors are involved in developing a C factor.

Selection of the correct C factor is difficult because there are many choices. However, changing the C factor of the farming system is one of the easiest, most effective ways of reducing soil loss. For example, a field with continuous corn that is fall plowed will have approximately 10 times as much soil loss annually as the same field using a corn-wheat-meadow rotation with spring plowing.

The information in Table 7.3 was developed for a conventional moldboard plow system with various crop rotations and a high level of fertility. High fertility means an average yield of 75+ bushels per acre of corn. For lower fertility fields, soil loss may be 10-25% greater. The C value increases as the hazard for erosion increases. Close-growing crops such as wheat and meadow reduce the C factor. Continuous wheat has a C value of 0.21, which is 55% of fall plowed continuous corn with residue left.

TABLE 7.3 - C factors for cropland--conventional tillage

| Cropping System | Spring Plow, Residue Left | Fall Plow, Residue Left | Spring Plow, Residue Removed* | Fall Plow, Residue Removed* |
|---|---|---|---|---|
| Cont. Sb** | .42 | .46 | .54 | .58 |
| CSb** | .40 | .44 | .52 | .56 |
| CCSb** | .39 | .43 | .51 | .55 |
| Cont. C | .38 | .42 | .50 | .54 |
| CCOx | .24 | .27 | .27 | .30 |
| CCWx | .22 | .26 | .24 | .28 |
| COx | .17 | .19 | .21 | .23 |
| CWx | .15 | .17 | .19 | .21 |
| CCCOM | .15 | .17 | .19 | .21 |
| CCCWM | .14 | .16 | .18 | .20 |
| CCOM | .12 | .13 | .18 | .19 |
| CCWM | .12 | .13 | .16 | .17 |
| CxCOM | .11 | .12 | .15 | .16 |
| CxCWM | .11 | .12 | .14 | .15 |
| CCOMM | .10 | .11 | .14 | .15 |
| CCWMM | .095 | .11 | .13 | .14 |
| CxCOMM | .090 | .10 | .10 | .11 |
| CxCWMM | .089 | .10 | .11 | .12 |
| CCOMMM | .082 | .09 | .12 | .13 |
| CCWMMM | .079 | .09 | .11 | .12 |
| CxCOMMM | .076 | .085 | .10 | .11 |
| CxCWMMM | .075 | .085 | .093 | .103 |
| COWMM | .067 | .075 | .091 | .101 |
| COM | .060 | .070 | .097 | .107 |
| CWM | .052 | .060 | .088 | .096 |
| COMM | .046 | .050 | .074 | .078 |
| CWMM | .040 | .050 | .067 | .077 |
| CWMMM | .033 | .037 | .054 | .058 |
| CWMMMM | .028 | .032 | .046 | .050 |

C = Corn - Sb = Soybeans W = Winter grain M = Meadow
O = Spring grain X = Cover or green manure crop
* Residue removed includes corn stover and grain stover.
** Rotations with soybeans are calculated with 1500 pounds residue for each year of soybeans.
A factor for plow planting may be calculated by multiplying the factor for conventional tillage by 0.6.

As the amount of residue increases and is left on the surface, the hazard of erosion is decreased. Table 7.4 has the C values for strip tilled (33% soil surface tilled) and no-tillage (10% soil surface tilled) farming systems.

TABLE 7.4 - C factors for cropland--conservation tillage

| | 33% Soil surface tilled | | | | | | | 10% Soil surface tilled | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROW CROP RESIDUE* | | | | | SOD RESIDUE** | | ROW CROP RESIDUE* | | | | | SOD RESIDUE** | |
| CROPPING SYSTEM | 1500 lb | 2000-3000 lb | 3000-4000 lb | 4000-6000 lb | 6000+ lb | 2000-3000 lb | 3000+ lb | 1500 lb | 2000-3000 lb | 3000-4000 lb | 4000-6000 lb | 6000+ lb | 2000-3000 lb | 3000+ lb |
| Cont.R*** | .311 | .243 | .188 | .131 | .080 | .034 | .027 | .249 | .192 | .130 | .070 | .030 | .016 | .008 |
| RRROx | .287 | .245 | .194 | .173 | .131 | .037 | .032 | .251 | .198 | .155 | .135 | .102 | .024 | .018 |
| RROx | .253 | .223 | .200 | .177 | .161 | .038 | .033 | .229 | .205 | .181 | .165 | .123 | .028 | .021 |
| RRROM | .197 | .156 | .123 | .089 | .058 | .031 | .027 | .160 | .125 | .088 | .052 | .028 | .020 | .015 |
| RROM | .168 | .134 | .107 | .078 | .053 | .030 | .026 | .138 | .109 | .078 | .048 | .028 | .021 | .017 |
| RROMM | .136 | .109 | .087 | .064 | .043 | .025 | .022 | .111 | .088 | .063 | .039 | .023 | .018 | .015 |
| RROMMM | .114 | .091 | .073 | .054 | .037 | .022 | .019 | .093 | .074 | .054 | .034 | .020 | .016 | .013 |
| ROM | | | | | | .028 | .026 | | | | | | .022 | .020 |
| ROMM | | | | | | .023 | .021 | | | | | | .018 | .016 |
| ROMMM | | | | | | .019 | .018 | | | | | | .015 | .014 |
| ROMMMM | | | | | | .017 | .015 | | | | | | .014 | .013 |

The quantities of crop residue listed above refer to the amounts of cover in pounds per acre still remaining on the soil surface after planting.

* When meadows or green manure crops are included in the rotation, the calculations are based on plowing in the conventional manner for the first year corn and the balance of the years of corn are mulch tilled.

** When planted in sod residue, calculations are based on planting in sod without plowing for first year corn. All succeeding corn is planted with 6000+ lbs of residue cover.

*** R = Corn or Soybeans. The amount of residue produced by the crop determines the erosion potential.

To estimate amount of residue from crop yields, consider that for each pound of corn produced there is one pound of residue (100 bushels per acre of shelled corn equals 5,600 pounds per acre of residue). For each bushel of small grain, there are 100 pounds of residue (30 bushels per acre wheat equals

3,000 pounds of residue per acre). Soybean residue usually averages 1,500-2,500 pounds per acre. For sod residue, estimate the amount of hay the residue would make (3,000 pounds per acre gives optimum erosion control).

Compare the difference between spring-plowed continuous corn with residue left (C of 0.38) and no-tilled continuous corn (10% soil surface tilled) with 6,000+ pounds of residue (C of 0.03). The reason for the large difference is that with no-till or other conservation tillage the surface is protected year-long. With conventional tillage, spring-plowed land is unprotected three or four months, while fall-plowed land may be unprotected up to nine months each year. Unfortunately, few C values have been evaluated for other reduced tillage systems. Surface residue can be estimated using Table 7.5.

TABLE 7.5 - C factors for annual cover and various quantities of mulch

| Cover or mulch | C factor |
|---|---|
| bare areas | 1.0 |
| 1/4 ton straw mulch | .52 |
| 1/2 ton straw mulch | .35 |
| 3/4 ton straw mulch | .24 |
| 1 ton straw mulch | .18 |
| 1 1/2 ton straw mulch | .10 |
| 2 ton straw mulch | .06 |
| 3 ton straw mulch | .03 |
| 4 ton straw mulch | .02 |
| annual cover | .15 |

A chisel plow reduces surface residue 20-50%, and a disk reduces surface residue about 50% each time it is used.

To convert pounds of residue to percent cover, use Figure 7.2.

Doublecropping is also an effective way of reducing soil erosion since a growing crop is always on the soil. Planting soybeans in wheat stubble not only saves time and moisture but also reduces soil erosion. Values of C for double cropping are comparable to those for conservation tillage.

Table 7.6 points out the importance of the amount and type of cover in pastureland. The greater the ground cover, the lower the C value. Notice that grass cover gives greater protection than weeds. Tall fescue pasture with an excellent stand of grass would have no appreciable raised canopy. Cover that contacts the ground is grass (G); its percent cover is 95-100. The C factor is 0.003. A bluegrass pasture with a poor stand of grass would have a raised canopy of tall weeds and a 25% canopy cover; the grass covers 60% of the ground. The C factor is 0.038.

TABLE 7.6 - C factors for permanent pasture, rangeland and idle land

| Vegetal Canopy | | | Cover That Contacts the Surface | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type and Height of Raised Canopy[2] | Canopy Cover[3] | Type[4] | Percent Ground Cover | | | | | |
| | | | 0 | 20 | 40 | 60 | 80 | 95-100 |
| Column No.: | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| No appreciable canopy | | G | .45 | .20 | .10 | .042 | .013 | .003 |
| | | W | .45 | .24 | .15 | .090 | .043 | .011 |
| Canopy of tall weeds or short brush (0.5 m fall ht.) | 25 | G | .36 | .17 | .09 | .038 | .012 | .003 |
| | | W | .36 | .20 | .13 | .082 | .041 | .011 |
| | 50 | G | .26 | .13 | .07 | .035 | .012 | .003 |
| | | W | .26 | .16 | .11 | .075 | .039 | .011 |
| | 75 | G | .17 | .10 | .06 | .031 | .011 | .003 |
| | | W | .17 | .12 | .09 | .067 | .038 | .011 |
| Appreciable brush or bushes (2 m fall ht.) | 25 | G | .40 | .18 | .09 | .040 | .013 | .003 |
| | | W | .40 | .22 | .14 | .085 | .042 | .011 |
| | 50 | G | .34 | .16 | .085 | .038 | .012 | .003 |
| | | W | .34 | .19 | .13 | .081 | .041 | .011 |
| | 75 | G | .28 | .14 | .08 | .036 | .012 | .003 |
| | | W | .28 | .17 | .12 | .077 | .041 | .011 |
| Trees but no appreciable low brush (4 m fall ht.) | 25 | G | .42 | .19 | .10 | .041 | .013 | .003 |
| | | W | .42 | .23 | .14 | .087 | .042 | .011 |
| | 50 | G | .39 | .18 | .09 | .040 | .013 | .003 |
| | | W | .39 | .21 | .14 | .085 | .042 | .011 |
| | 75 | G | .36 | .17 | .09 | .039 | .012 | .003 |
| | | W | .36 | .20 | .13 | .083 | .041 | .011 |

[1] All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.

[2] Average fall height of waterdrops from canopy to soil surface: m = meters.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

[4] G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral-root network near the surface, and/or undecayed residue.

Soil erosion from wooded areas is almost always low. Table 7.7 shows appropriate C values for woodlands.

TABLE 7.7 - C factors for woodlands

| Stand Condition | Tree Canopy % of Area[1] | Forest Litter % of Area[2] | Undergrowth[3] | "C" Factor |
|---|---|---|---|---|
| Well Stocked | 100-75 | 100-90 | Managed[4] | .001 |
| | | | Unmanaged[4] | .003-.011 |
| Medium Stocked | 70-40 | 85-75 | Managed | .002-.004 |
| | | | Unmanaged | .01 -.04 |
| Poorly Stocked | 35-20 | 70-40 | Managed | .003-.009 |
| | | [5] | Unmanaged | .02 -.09[5] |

[1] When tree canopy is less than 20%, the area will be considered as grassland, or cropland for estimating soil loss.

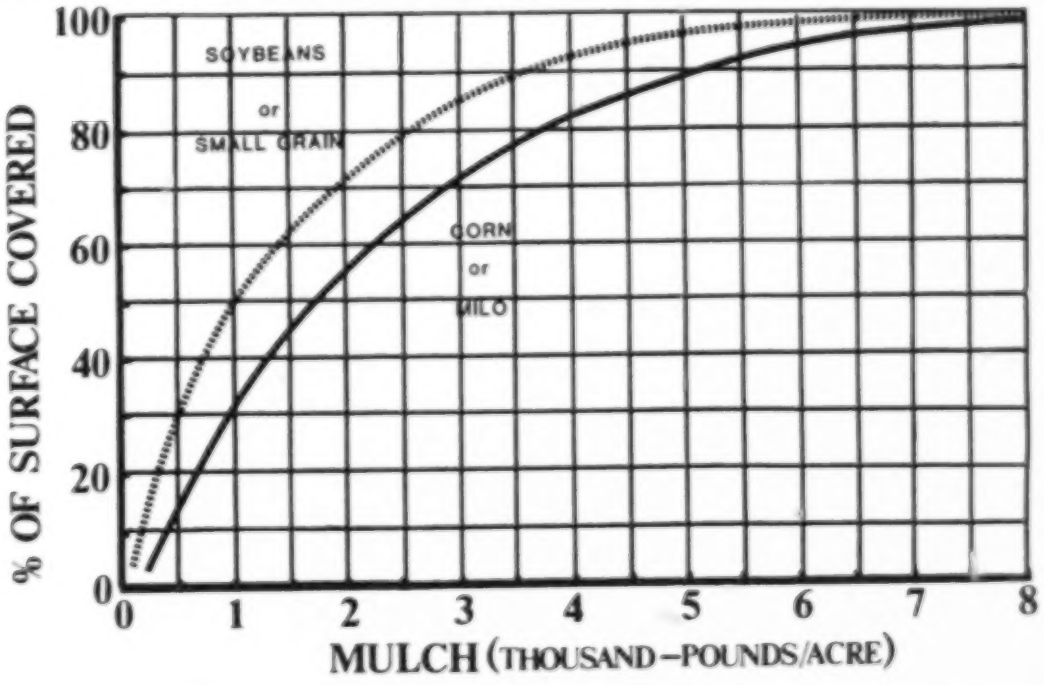
[2] Forest litter is assumed to be at least two inches deep over the percent ground surface area covered.

[3] Undergrowth is defined as shrubs, weeds, grasses, vines, etc., on the surface area not protected by forest litter. Usually found under canopy openings.

[4] Managed—grazing and fires are controlled.
Unmanaged—stands that are overgrazed or subjected to repeated burning.

[5] For unmanaged woodland with litter cover of less than 75%, C values should be derived by taking 0.7 of the appropriate values in Table 5. The factor of 0.7 adjusts for the much higher soil organic matter on permanent woodland.

FIGURE 7.2 - Relation of percent cover to dry weight of uniform residue



Erosion control practices (P) - Erosion control practices include contour tillage, contour strip-cropping and terracing. Contouring and strip-cropping have been assigned P values based upon slope; see Table 7.8.

TABLE 7.8 - P factors for erosion control practices

| % slope | Up-down hill | Contouring | Contour strip cropping |
|---|---|---|---|
| 2-7 | 1.0 | 0.5 | 0.25 |
| 7-12 | 1.0 | 0.6 | 0.30 |
| 12-18 | 1.0 | 0.8 | 0.40 |
| 18-24 | 1.0 | 0.9 | 0.45 |

Contouring is the practice of planting all row crops and performing all tillage across the slope rather than with the slope. It is most effective on slopes of 2-8% where it reduces erosion 50% when compared to up-and-down hill farming. To get full benefit of contouring, fields should be relatively free of gullies, and waterways should be grassed. Slope length limits for contouring are given in Table 7.9.

TABLE 7.9 - Slope length limits for contouring

| Land slope (%) | Maximum slope length (in feet) |
|---|---|
| 2 | 400 |
| 4-6 | 300 |
| 8 | 200 |
| 10 | 100 |
| 12 | 80 |
| 14-24 | 60 |

Contour strip-cropping is the practice of alternating strips of sod with row crops or small grain, all planted on the contour. The sod strips trap much of the sediment, and soil loss from the field is only one-half that of contouring alone. Strip widths range from 60 feet on steep, 13-18% slopes, to 100 feet for 2-7% slopes. Actual widths can be adjusted to fit machinery. Strip-cropping is not commonly practiced in Missouri, but it is an alternative.

Terracing is a very effective means of erosion control because it divides the slope into segments equal to the terrace spacing. Much of the effectiveness of terraces comes from reducing the LS factor in the soil loss equation. With terracing, as much as 90% of the soil moved to the channel will stay in the channel. This soil is not lost from the field and may result in extra terrace maintenance.

If the crop is planted on the contour with terraces, use a P value from Table 7.8. This will estimate the soil loss between terraces. Only about 20% of this will finally be lost from the field. The remainder will be trapped in the terrace channel and waterway.

**Acceptable Soil Loss (T)**

One important factor not given in the USLE is the Soil Loss Tolerance Factor. This factor (Table 7.1) denotes the maximum level of soil erosion that still permits a high level of crop productivity. Soils have been given a T factor ranging from one to five tons per acre per year. This simply implies that some soils can tolerate a one-ton-per-acre-per-year soil loss, and others can tolerate a yearly soil loss of five tons per acre--while still maintaining indefinite productivity. Additional T values can be obtained from SCS.

**Developing a Soil Conservation Plan Using the USLE**

The Universal Soil Loss Equation can be used to estimate soil loss, to point out factors that cause erosion, and to present alternatives for controlling erosion. The use of contouring as well as reduced tillage systems that maintain much of the crop residue on the surface can reduce soil loss to acceptable levels in many cases. Terraces and waterways will be needed for many other situations.

A workable soil and water conservation plan will usually be a combination of all these various parts. Considerable thought should be used so that the land user can develop the best plan that fits the overall goals.

The primary purpose of the soil loss equation is to help select adequate soil and water conservation practices for farm fields. The following example illustrates the use of the equation.

Given: Assume a 300-foot-long field in Knox County on Mexico silt loam (claypan type) soil with a 3% slope. Corn and soybeans are rotated. The field is spring plowed up and down the slope, and the residues are turned under. Yields are usually greater than 75 bushels of corn. Using the USLE (A = RxKxLSxCxP), calculate the average annual soil loss.

R = 200 Figure 1
K = .40 Figure 2
LS = 0.6 Figure 3
C = 0.40 Figure 4
P = 1.0 Figure 10
A = 200x0.40x0.6x0.40x1.0 = 19.2 tons per acre per year

This soil loss is well in excess of the tolerable yearly soil loss (T) of three tons per acre. At this rate, an inch of topsoil would be lost in an average of 8-10 years.

Management decisions influencing soil loss are usually made by affecting C or P in the equation. The factor L can be changed by terracing. The other factors (R, K and S) are essentially fixed. If the tolerable soil loss (T) is substituted for A, the required CP factor can be found. Using the previous example:

CxP = T/RxKxLS or
CxP = 3/200x0.40x0.6 = 0.06

If planting and tillage are done on the contour, P = 0.5, then for CxP to equal 0.06, choose a system with a C factor of 0.12 or less. From Table 7.3 with the same spring plow tillage as before, a rotation of corn-corn-wheat-meadow will lower C to 0.12. By using conservation tillage the C factor can be reduced to an acceptable level by maintaining 1 1/2 tons of mulch per acre (see Table 7.5). Using no-till (10% surface tilled, Figure 7.4) with 6,000+ pounds of residue per acre with continuous row crop has a C of 0.03. Therefore, soil loss would average one-half the goal of three tons per acre per year, even without contouring.

**Summary**

The Universal Soil Loss Equation is a very useful tool in controlling soil erosion. The equation is used to estimate annual soil loss from sheet and rill erosion on individual fields or farms. Conditions such as rainfall, soil type, crop sequence, conservation practices and topography are all taken into account. Specialists at the Soil Conservation Service and the University of Missouri use the USLE when developing soil conservation programs for farmers.

**Credits**

UMC Extension Division publications

a) M117: Best Management Practices for Erosion and Sediment Control
b) MX121: Concepts and Use of the Universal Soil Loss Equation
c) G1560: Estimating Soil Losses in Northern Missouri

UNIT - SOIL CONSERVATION

Lesson 8: Agency Assistance

Many variables are involved in soil conservation--farming operations, cost of conservation practices, soil types, slope length and steepness. A farmer does not have to fight the battle alone, however; government agencies are available to assist.

**Federal, State and Local Agencies**

Several federal, state and local agencies work with Missouri farmers to solve soil erosion problems. The SCS is present in local conservation districts because individual landowners organized the districts when they recognized erosion as a problem in the 1930s. Refer to Lesson 1 for more historical background on the formation of the SCS and conservation districts.

Federal

1. USDA Agricultural Stabilization and Conservation Service (financial assistance)
2. USDA Farmers Home Administration (conservation loans)
3. USDA Soil Conservation Service (technical and financial assistance)

State

1. Missouri Department of Natural Resources (financial assistance through Soil and Water Conservation Districts)
2. University Extension, University of Missouri (research and education)
3. Missouri Department of Conservation (plant materials and technical assistance)
4. Missouri Department of Agriculture (conservation loans)

Local

111 Soil and Water Conservation Districts statewide (technical and financial assistance)

**SCS and Soil and Water Conservation District Assistance**

For a farmer, the bottom-line question is, "Will the system satisfactorily solve erosion problems for me?" To best answer that question, a farm-by-farm and field-by-field analysis is necessary. Such an analysis is the best approach to planning a complete farm soil conservation system.

Help with determining current and projected soil losses is available through the local Soil and Water Conservation District and the Soil Conservation Service. All planning and technical services provided by SCS are free to the farmer.

SCS conservationists are trained to aid individuals in designing a system that's best suited in each case. They use the Universal Soil Loss Equation and other tools to help compare the effectiveness of various systems. The SCS conservationist can help determine the probable effects of omitting, adding or substituting practices from individual systems.

Once a system is designed, financial assistance is offered through many sources. The SCS and local Soil and Water Conservation District can answer questions about the availability of financial assistance for implementation of soil conservation systems.

The federal Food and Security Act of 1985 created a series of soil conservation regulations. Landowners and operators receiving USDA farm program payments are subject to these regulations. The four components of the law are Sodbuster, Swampbuster, Conservation Compliance and Conservation Reserve. People who farm highly erodible land need to keep up-to-date on the conservation requirements and adopted soil conservation practices recommended by SCS to remain eligible for USDA farm program payments.

**Summary**

Seldom can a single soil conservation practice solve all erosion problems on a farm. After a rainstorm it is apparent that the fields with adequate protection are those protected by a combination of soil conservation practices.

**Credit**

"Soil Conservation Systems for Missouri." Missouri Association of Soil and Water Conservation Districts, 1983.

"Losing Ground: Iowa's Soil Erosion Menace and Efforts to Combat It." Des Moines: Soil Conservation Service, 1986.